Upper Mississippi 9-Foot Channel Project
History (Locks and Dams 3 through 10)
Upper Mississippi River between Minneapolis,
Minnesota, and Guttenberg, Iowa
Red Wing vicinity
Goodhue County
Minnesota

HAER No. MN-20

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
Rocky Mountain Regional Office
National Park Service
U. S. Department of the Interior
P. O. Box 25287
Denver, Colorado 80225

HISTORIC AMERICAN ENGINEERING RECORD

Upper Mississippi River 9-Foot Channel Project History (Locks and Dams 3 through 10)

HAER No. MN-20

Location: Upper Mississippi River between Minneapolis, Minnesota, and Guttenburg, Iowa, Red Wing vicinity, Goodhue County, Minnesota

Builder: U. S. Army Corps of Engineers

Present Owner: United States Government
U. S. Army Corps of Engineers
St. Paul District

Present Use: River navigation/hydrology control

Significance: The Upper Mississippi Lock and Dam Project represents one of the largest and most ambitious of such undertakings. With roots in the Progressive Era, the project was adopted by New Deal proponents to serve the needs of public employment during the Great Depression. Its successful completion turned the upper reaches of one of the largest rivers, the Mississippi River, into a intra-continental canal and settled the questions of a fully navigable interior river system through the Midwest. Completion of the system helped allay economic inequities in commercial rail and water freight rates brought about as a result of the opening of the Panama Canal. Although significantly altering the environment of the upper Mississippi, the project also served as an impetus for the upgrading of municipal drinking water and sewage disposal systems, as well as providing new recreational opportunities; thus, in the end, proving generally beneficial to public welfare.

Historian: William Patrick O'Brien
October 1987

ACKNOWLEDGEMENTS

Thanks to various individuals and organizations are in order regarding the research, writing, and assembling of this report. Mr. Dave Berwick and Dr. John Anfinson of the St. Paul District Corps of Engineers' Environmental Division provided not only the original impetus for the project, but valuable information and consultation as well. Their understanding and excellent cooperation is very much appreciated. Special thanks go to Mr. Alan Perry of the Kansas City branch of the National Archives and Record Center, Mr. Ken Shanks of the Chicago branch, Ms. Thelma Martin of the Civilian Records Center,St. Louis branch, and Ms. Marianne Hageman of the St. Paul District Library and Archives. All were helpful and professional; all went beyond the normal efforts in attempting to accommodate needs and schedules. Appreciation for the same is gratefully acknowledged. Thanks are also tendered to those various individual historians and technicians of the U. S. Army Corps of Engineers who provided helpful insights and information during the course of the project. Also, particular thanks go to those lockmasters and personnel of the St. Paul District who took the time to discuss their various installations during the inventory phase of the project. Without their valuable input, assistance, and hospitality, the project's completion would have been both far less efficacious and entertaining. Finally, thanks to the professional and secretarial staff of the Rocky Mountain Regional Office of the National Park Service who patiently assisted in the administration and publication of this document.

TABLE OF CONTENTS

FOREWORD

The following Historic American Engineering Record (HAER) history documents the technological significance of Lock and Dam Systems 3 through 10. Locks and Dams 3 through 10 are part of the 26-unit, 9-foot channel project on the Upper Mississippi River, constructed between St. Louis, Missouri, and Minneapolis, Minnesota, in 1927-1940, under the supervision of the U. S. Army Corps of Engineers.

The report is divided into three sections. The first section, "Administrative History," provides a brief political and economic historical overview of the project. The second section, "History of Technology," traces the development of late-19th and early-20th century prototypical lock and dam systems and analyzes their influence on the Upper Mississippi project, particularly the Ohio River 9-Foot Channel Project, 1910-1929. The third section, an inventory in outline format, describes the individual lock and dam complexes, their construction histories including construction methods and unique design considerations, and a review of the working technology of each system. Also included in this last section is a description of the configuration of each complex and a chronology of changes to the individual complexes since that time.

INTRODUCTION

The concept of a history and inventory of the Upper Mississippi River 9-Foot Channel Project resulted from various dialogues between the U. S. Army Corps of Engineers and cultural resource management professionals employed by the National Park Service, U. S. Department of the Interior. After the project was determined eligible for listing in the National Register of Historic Places in 1986, steps were taken to ensure its adequate documentation as an important resource on the history of technological development in the United States. A cooperative project between the St. Paul District of the U. S. Army Corps of Engineers and the Historic American Engineering Record (HAER) of the National Park Service's Rocky Mountain Regional Office was begun in August 1986. The project included the documentation of the nine lock and dam complexes located in the St. Paul District, including research of their administrative and technological significance and photographic documentation. Records of the 9-foot Channel Project on the Upper Mississippi River (1930-1940) were consulted at National Archives repositories in Chicago, Illinois, and in Kansas City and St. Louis, Missouri. The thousands of linear feet of records generated by the 10-year undertaking provided a solid basis for both administrative and technological histories. The approximately 10,000 separate drawings stored in the St. Paul District Office and the hundreds of period photographs located both there and at individual sites likewise provided an amazing wealth of information. Inventories for contemporary photographs were accomplished during the fall of 1986 and the spring and summer of 1987 concurrently with research for the historical narrative and technical inventory portions of the study. In late summer and fall of 1987, the staggering amounts of primary source documentation were distilled and synthesized into the following history and inventory.

The resulting study is far from definitive. It does, however, provided a base on which other historians may build. It is hoped that colleagues with an interest in both the late Progressive and New Deal Administrations and the history of technological development in the United States will continue to inspect and analyze the Upper Mississippi River 9-Foot Channel Project and similar projects of that era to their place in the larger context of both technological and American history.

ADMINISTRATIVE HISTORY

The U. S. Army Corps of Engineers' 9-Foot Channel Project of the Upper Mississippi (1927-1940) resulted from years of dialogue concerning river navigation projects. A navigable channel from St. Louis, Missouri, to Minneapolis, Minnesota, had long been the dream of midwestern commercial interests.[1] Even after Congress authorized the establishment of a six-foot channel in 1907, barges ascending the Mississippi were forced to unload cargoes in the Cairo/St. Louis vicinity for transfer to craft having shallower drafts. Such activity incurred tremendous costs. Also, the opening of the Panama Canal in 1914 forced Midwest business interests to rethink future plans

concerning commercial transportation. Completion of the Central American project impacted commercial freight transportation costs, causing the interior of the United States to experience inequities in commercial rail transportation rates due to cheaper inter-coastal shipping costs. Secretary of Commerce Herbert Hoover noted in 1926 the effect of the Panama Canal on the economic profile of the Upper Mississippi region. He stated that shipping rates thus affected by the opening of the canal had brought New York closer to San Francisco, while putting Chicago farther away from the Pacific Coast area: "In other words, Chicago has moved 336 cents away from the Pacific Coast, while New York has moved 224 cents closer to the Pacific Coast." Hoover stated that this change in costs affected all of the Midwest. As a result, interest increased in a fully navigable river channel as part of a national intra-coastal waterway that would provide cheaper alternatives to rail transport.[2]

In 1927, the Rivers and Harbors Act provided for a survey of the Mississippi, from its confluence with the Missouri River to Minneapolis, to assess the feasibility of a 9-foot channel on the upper river. Twenty-six lock and dam complexes were ultimately constructed to improve the river's effective commercial usage. Administration for the project was placed under the Upper Mississippi River Valley Division (U.M.V.D.) located in St. Louis and was divided into three administrative districts, the St. Louis District (St. Louis to Clarksville, Missouri), the Rock Island District (Clarksville to the Wisconsin River), and the St. Paul District (Wisconsin River to Minneapolis).[3]

Controversy plagued the 9-Foot Channel Project from its beginning. Studies conducted between 1927 and 1930 indicated that the project would have significant environmental impacts and that construction costs would be substantial. Nevertheless, authorization for the development of a 9-foot, low-water channel on the Upper Mississippi was passed by Congress under the Rivers and Harbors Act of 1930, even though final reports on the ecological impacts of the program were not available until the following year. Another controversial item centered around the question of the proposed system's singular function. Unlike the Ohio or Tennessee River Valley projects, the Upper Mississippi 9-Foot Channel Project would serve only commercial transportation and business interests. Broader public benefits, such as hydroelectric power or flood control were not a part of its scheduled services. The question of hydroelectric power as an adjunct function of the project surfaced from time to time during the 1930s; however, the proposal did not receive serious consideration due to various technical problems. In efforts to quell initial controversy and accusations of special interest considerations, positive effects on employment, recreation, and wildlife were regularly cited by proponents as incidental benefits of the program. Although such words initially rang hollow in the ears of many who suspected the project as a regional "pork barrel" undertaking, the project's benefit to Depression-era employment is unquestionable. During peak years, as many as 600 to 800 men averaged the work force at each construction site. The year 1934 witnessed 5,500 employees at work in the St. Paul District; in 1935,

3,500; in 1936, 4,200; and in 1937, 4,000. Directives instructing the use of local labor forces and emphasizing use of labor-intensive methods also served to give the project a more positive image, helping to offset its pork barrel and special business interest aspects.[4]

But, as successful as the undertaking may have been as a New Deal employment tool, it nevertheless received opposition from various groups who perceived the project as detrimental to their interests. Interestingly enough, early opponents even included members of the Corps of Engineers. Maj. Charles L. Hall, district engineer for the Rock Island District, stated in the 1927 congressional report that a 9-foot channel was not economically feasible, causing great outcry among Minneapolis business interests. In 1929, a request from the Izaak Walton League to both President Hoover and U. S. Army Chief of Engineers Maj. Gen. Edgar Jadwin regarding the proposed channelization's impact on wildlife prompted Brig. Gen. Thomas H. Jackson to request an additional study from Maj. Hall concerning the impact of such a development. Again, Hall's findings were not positive. In an address to the School of Wildlife Protection in McGregor, Iowa, Hall stated that the project would "radically change" the wildlife of the region. And, again, the outcry from the vested interests was immediate and violent. The Minneapolis Journal berated Maj. Hall in an editorial, stating that the major's duties were "neither floral or faunal, but engineering," and that his time would be better spent in areas in which he had been specifically trained.[5]

The ill-fated Maj. Hall may have been the victim of political storms beyond his control. What upriver business interests saw as his recalcitrance was in reality only a direct reflection of Corps policy. Hall's superiors noted their displeasure with his findings. He was relived of his duties as a member of the six-member team entrusted to conduct a "more thorough" survey as ordered by the Office of the Chief of Engineers. Interestingly enough, however, Chief of Engineers Maj. Gen. Jadwin did not support the channelization, either. He chose, instead, to focus on flood control problems of the Mississippi, especially after the devastating 1927 flood. He also opposed reservoir flood control on the river, in the midst of influential political support for the concept. Jadwin's views reflected turn-of-the-century views of Progressive conservationists and Corps officials; projects should stand on their own merit and should be managed by logical planning and trained personnel. They should not be the product of special interest pork barrel politics. Such attitudes, however lofty and professional, refused to recognize the political realities attendant in the proposed 9-Foot Channel Project. The Progressive line of thought resounded arrogantly for some politicians. Certainly Jadwin's acknowledgement that movable dam systems constituted the only logical way to assure a 9-foot channel on the Upper Mississippi and his concurrent refusal to endorse the project looked to some as contradictory as well as proprietary and haughty. But true to Progressive principles, Jadwin's staff, in the person of Maj. Hall, bore the burden of preparing the professional reports stating that the environment would be compromised. Whether out of professional integrity or personal arrogance, Jadwin evidently chose to stand in a somewhat

duplicitous middle ground. It is unclear why Jadwin refused to support the concept, while at the same time facilitating the reports of a committee that ultimately rubber-stamped the project. Although definitive documentation is presently lacking, such facts as are available seem to reflect the actions of a man caught in a political bind. Publicly, he tacitly cooperated. Privately, he refused to acquiesce.[6]

Maj. Gen. Jadwin's refusal to support the project manifested itself in various public ways. For example, in an address to the World Conference on Engineering held in Tokyo, Japan, during the same period, Jadwin made no reference to the proposed channelization, although he mentioned most of the other major waterway projects of importance in the United States. However, other Corps staff were more easily led. The "more thorough" report requested by the Office of the Chief of Engineers recommended quick approval of the project. But the approval did not come quickly enough for Jadwin's career. His replacement upon the election of President Herbert Hoover with Maj. Gen. Lytle Brown as Chief of Engineers spelled an end to Corps reluctance regarding the 9-Foot Channel Project. Ten senior officers were passed over to assure Brown of the appointment. Obviously, further controversy over the project was to be held to a minimum.[7]

Replacement of personnel and the angry verbiage of Minneapolis business interests did not quiet the complaints lodged against the channelization project. A growing national environmental awareness fostered by the work of Mississippi Valley native Aldo Leopold and other conservationists caused many to reevaluate the river valley environment in light of the lock and dam projects. Controversy over the construction of projects such as Hetch Hetchy in the San Francisco area (1907-1913) and the Keokuk Power Dam (1910-1913) prompted those concerned with the Upper Mississippi environment, such as Will Dilg, founder of the Izaak Walton League of America, to take active roles in opposition of the project. Previous controversies on the Upper Mississippi regarding environmental concerns had surfaced in 1923, when a proposal to drain approximately 30,000 acres of the Winneshiek Bottoms, a 30-mile area on the Wisconsin side of the Mississippi River, resulted in a fight between conservationists and developers, ending in a victory for the conservationists and the establishment of the Upper Mississippi Wildlife Refuge by President Calvin Coolidge in 1924. Now, six years later, questions centered around flooding instead of drainage. The lock and dam system required construction of large slackwater pools to provide the necessary water levels for river navigation at all seasons. Such permanent large scale flooding of formerly non-inundated and seasonally-inundated lands stood to appreciably affect the ecology of the project area.

The hearings in Washington, D.C., concerning the 1930 Rivers and Harbors Act did not last two days. Supporters comprised the bulk of testimony (16 persons speaking before the committee) and all supported the project. Of the 16 people, ten were Congressmen. Other supporters included State representatives, representatives of shipping companies, and the president of the St. Paul

Chamber of Commerce. The Rivers and Harbors Committee unanimously recommended approval of the Shipstead Amendment, introduced by Senator Henrik Shipstead of Minnesota. The senator had quickly proposed this amendment upon the introduction of the 1930 River and Harbors Act to Congress. Initially, the 9-Foot Channel Project had not been included in the legislation, requiring quick action on the part of Shipstead. Initial introduction of the bill included only funding for three dams. An amendment was introduced for complete funding by Minnesota representatives. Objections were raised, and a suggestion to stop funding until the final report was submitted was considered but rejected. Finally, after overt support and covert opposition, the 9-Foot Channel Bill was signed into effect by President Hoover on July 3, 1930. Public opposition to the project was not voiced in the congressional hearings. But it wasted little time in manifesting itself immediately thereafter.[8]

Public and private opposition to various aspects of the project forced the Corps of Engineers to address various concerns. Opposition to Lock and Dam 4 in the Wabasha County, Wisconsin, area over pool elevations and their effect on the environment finally led to a series of public hearings. The Corps held a public meeting at Wabasha, Wisconsin, on February 26, 1931, concerning the first of the lock and dam complexes to be constructed in the St. Paul District. Assurances were proferred by the Corps to the concerned parties: the pooled water elevations would be changed from 670 median sea level (m.s.l.) to 667 m.s.l., with provisions for adjustment to 670 m.s.l. in the future, if warranted. "Ample time" would be given to all concerned to take the necessary "protective measures" in the event of such an adjustment was included in the report. Testimony from health and environmental experts stating that the proposed pool elevation would have negative consequences for the river valley environment resulted in the Corps' reconsideration of the proposed water elevations. But the route by which the Corps finally arrived at its final conclusion to alter original plans proved arduous and difficult. The national organization of the Izaak Walton League scheduled a meeting in Winona, Wisconsin, on March 7, 1931, to considered the proposal "to ascertain the possibilities for development of the refuge area if a proper type of dam is constructed." It also served to focus public awareness of the issues and to intensify pressure to alter proposed water elevations. It was finally agreed that the pool elevation would be changed from 670 m.s.l. to 667 m.s.l. The three-foot variance guaranteed substantial protection from an otherwise negative impact.[9]

The Corps did not give up the three feet easily. In a press release in August 1931, Lt. Col. Wildurr Willing stated that the results of the public concern over the project had led the Corps to recommend that the dam at Alma, Wisconsin, be constructed with a 667 m.s.l. "for the present," but that the structures built be "readily adaptable to 670 m.s.l. at whatever time in that the Corps felt it necessary to raise the pool level. . . . Ample time will be given to all concerned to take the necessary protective measures." Such rhetoric amounted to little more than embarrassed pronouncements of military

engineers caught in a mistake. The need to raise the pool level in the future was questionable. In a memorandum commenting on a draft report on the Alma Dam, Head Engineer William McAlpine stated that he felt the "public is entitled to a frank statement of our intentions. One might infer from the paragraph suggested by Maj. Edgerton that there was a question as to whether even a 667 m.s.l. pool level would be practicable; certainly there is no intimation that it might be found possible or necessary to raise the pool to a higher level later on."[10]

Had the environmentalists been alone in their protests, they might well have been unable to effect any change in the pool elevation proposals. However, they were not the only ones that objected. Railroad companies saw channel improvements and river commerce as dangerous to freight transport business prerogatives. More immediately, the railroads' concern was somewhat the same as the environmentalists'--the proposed pool elevations promised to flood railroad rights-of-way. The railroads did not content themselves in the manner of the environmentalists, holding meetings and passing resolutions. A lawsuit was filed against the U. S. Government in 1932 regarding anticipated damage to railroad property as a result of the projected pooling of waters at Lock and Dam Site 4. A decision handed down by Judge F. A. Geiger of the U. S. District Court for the Western District of Wisconsin validated the railroads' complaints. The Federal Government was enjoined by the findings of fact and conclusions of law to desist from any further acts of property condemnation for lock and dam construction purposes at Alma, Wisconsin, constructing any non-navigable dam capable of impounding water at 670 elevation, or constructing any element that would raise crest elevations above 635.7 feet m.s.l.[11]

The judgment alarmed Government personnel. Such a decision could effectively bring the project to a half if not somehow mitigated. Original legislation under House Document No. 290 authorized specific administrative parameters for the project. The Corps now sought to enable the Chief of Engineers with the necessary discretionary authority to make changes in the original approved plans, so that lawsuits such as the one contemplated by the Chicago, Quincy and Burlington Railroad could be avoided. In a memorandum dated March 24, 1932, Col. George R. Spalding, U.M.V.D., noted that attorneys familiar with railroad legal matters should be retained by the U. S. Attorney General's office, so that cases requiring specialized legal expertise could be effectively handled and won. "The railway companies," noted Spalding, "with their final legal talen, are doing this very thing. They are fighting these cases jointly by exchanging briefs and combining defenses to defeat the government. Consequently, we are being consistently beaten in lower courts." Legislation was passed by a joint resolution of Congress and approved by the President on February 24, 1932, amending the original 1930 bill to give the Chief of Engineers authority to make necessary changes in design without requiring additional approval.[12]

The Corps wasted no time in implementing its new authority. Almost a year to the day of the Wabasha public hearing, an immediate change in plans by the

Corps of Engineers called for the pooling of waters at no more than 667 m.s.l. Previous rhetoric noting possible future needs to raise pooled waters to higher levels was noticeably absent. Secretary of War Patrick Hurley, in a letter dated March 4, 1932, to the Attorney General's office, called the final note in the controversy: "I transmit, herewith, an authenticated copy of the instrument executed by the Chief of Engineers modifying the plan, and shall be pleased if you will take such action as in your judgment is appropriate to relieve the Department of the restraint imposed by the decree of the district court." Four days later, a letter from Attorney General William D. Mitchell to Hurley noted that the U. S. Attorney at Madison, Wisconsin, "has been instructed to take appropriate proceedings to suggest to the Court of Appeals that, in view of the situation as now presented, the case is moot and to move for a mandate to the Court below to dismiss the case. You will be kept advised as to developments." The rail companies, in actions separate from but nevertheless in concert with environmentalists, thus effected some change in the course of the monolithic project.[13]

Controversy over the project continued. Opposition in the ranks of the Corps of Engineers had been effectively squelched. However, other Federal officials remained divided on the subject. In 1934, Jay N. Darling, Chief of the Bureau of Biological Survey, stated to reporters that the 9-Foot Channel Project would have serious consequences for wildlife and wildlife refuges in the Upper Mississippi region. The answer of Dwight F. Johns, District Engineer for the St. Paul District, reflected the evolution of Corps' thought regarding the project since the days of Maj. Gen. Jadwin's initial opposition in the late 1920s. The Corps was now among the project's staunchest supporters. Johns stated in a memorandum dated May 5, 1934, that while it was true that 38,000 of the 45,500 acres controlled by the wildlife and game refuge in the St. Paul District would be inundated, the results would be "materially offset by the large pool areas which will be available for wild bird life." The political lessons of the 1920s had not been lost on the Corps of Engineers.[14]

Complaints continued to be voiced by local populations even after the system was placed in full operation. The winter season presented particular problems when low water conditions necessitated "drawdowns" from slackwater pools, causing variations in feet rather than inches in water levels. Claims against the Federal Government, as in the case of Albert Gstrein of Stockholm, Wisconsin, alleging water problems and inundated lands as a result of the channel project, involved lengthy discussions regarding median rainfalls and various inspections by Corps and legal personnel. The Corps reports, however, continued to state that the system's effects on the surrounding environment were negligible and actually improved fish and wildlife habitats.[15]

In the end, political and economic considerations overrode any environmental or special interest outcry. The strong initial support of President Herbert Hoover and later adoption by the Roosevelt Administration, enabled the gigantic project to proceed despite all objections and controversies. The question of the lock and dam system's impact on the Mississippi River Valley environment, however, remains controversial even today.

Presidential support continued to be a hallmark of the immense undertaking throughout the project's course. The Hoover Administration's initial interests in a 9-foot channel on the Upper Mississippi found themselves recast, as of 1932, in the New Deal agendas of Franklin Roosevelt. On August 8, 1934, President Roosevelt stopped at Lock and Dam Site 5 during a vacation to inspect the general status of the 9-Foot Channel Project with Maj. Dwight Johns of the St. Paul District. A more detailed inspection trip was scheduled by the President for August 31 through September 8, 1936, originating at Minneapolis and ending at Memphis, Tennessee. All manner of preparations were made, including the equipping of Ellen, a boat from the Rock Island District with a specially-designed wheelchair elevator, airconditioning, kitchen crew, and other necessary appurtenances. Among other articles requisitioned for the President's use were cards, poker chips, and a large touring car (18 feet bumper-to-bumper).[16]

In the wake of political battles, economic depression, and a change in presidential administrations, the giant engineering undertaking spawned a giant organization. Substantial adjustments in the organizational structure of the St. Paul District needed to be made to accommodate the colossal nature and scope of the project, including the addition of personnel and civilian consultants. In 1923, the St. Paul District, under Maj. Charles F. Williams, consisted of the most minimum of personnel centered around the Chief Administrator, Charles Wade. Five years later, in 1928, an organizational restructuring, at the request of Western Division Engineer Gen. Thomas Jackson, began to prepare the St. Paul District for its function in the 9-Foot Channel program. Administrative and engineering functions were separated, "chains of command" were established in the engineering division, and other adjustments were made. Nine months of disagreements between Williams and Jackson over personnel resulted in the replacement of Maj. Williams as District Engineer by Col. Wildurr Willing. Willing served as head of the St. Paul District until 1933, at which time Willing was replaced by Maj. Dwight F. Johns. Johns continued to supervise the work on Locks and Dams 2 to 9 for the St. Paul District until 1937, when Capt. Frank K. Albrect served briefly as acting district head. In July of that year, he was replaced by Lt. Col. Phillip B. Fleming. Col. John Moreland assumed the position as head of the St. Paul District in October 1939, supervising the remainder of the work done under the program as of 1940.[17]

As construction commenced in 1930, Lt. Col. Willing headed the St. Paul District operation, assisted by Military Assistant for Special Assignments 1st Lt. Heath Twitchell. The remaining organization was divided into engineering and administrative functions. Inspection of hired labor work was handled by surveyman M. L. Betzel.

Actual engineering responsibilities were broken into three sections and drew from the very best professional personnel in the region. Section number one, headed by H. M. Anderly, supervised improvements on the Mississippi River from Minneapolis to the mouth of the Wisconsin River, as well as various

improvements on the St. Croix River. Included in Anderly's duties were the reconstruction of the Twin City Lock and Dam (Lock and Dam 1); the administration, survey, and inspection of the same; construction of the Hastings Lock and Dam; design, tests, and engineering details; plans and engineering files, and specifications as well as construction supervision of contracted work. Also under this section was responsibility for the operation and inspection of launch and motorboat repairs.

Anderly's section included an engineer, W. D. Fairchild; two assistant engineers, V. C. Funk and Joseph R. Johnson; and a junior engineer, E. J. Christenson (assigned to Fairchild). Christenson typified the young man just out of engineering school to whom the lock and dam project would mark the beginning of a lifetime vocation with the Corps as a civilian engineer. Christenson's career was marked by distinguished and exemplary service. Hired in 1927, he continued with the Corps for many years in a variety of assignments.[18]

A construction supervisor, William P. Schmoker, and a gasoline engineman, William G. Straub, were also included in Anderly's section. Under the construction supervisor were the bulk of the surveyors, the rock quarry overseer, dredger engineers, and miscellaneous workmen.

H. Vassant headed section number two, with duties pertaining to Hastings Lock and Dam flowage rights, St. Croix River permits above Stillwater, special investigations, and reports and other duties relating to the Federal Power Commission.

Section number three, headed by H. M. Hill, included flood control surveys; 9-Foot Channel surveys (particularly the location of dam sites and survey work); supervision of hydraulic testing at the University of Iowa for the Hastings Lock and Dam Project; studies for the Mississippi River Survey Board; engineering and operations of reservoirs at the Mississippi headwaters; other special studies including model studies; office studies; drafting, borings, gauges, and stream measurement; and survey parties.

Hill, employed by the Corps since 1927, graduated with honors from the University of Minnesota in 1923. That year, he entered service with the Coast and Geodetic Survey as a junior engineer. In 1924, he took a post at the University of Minnesota as an instructor of civil engineer, where he taught hydraulic engineering until 1928. His technical expertise and access to information and trained personnel had important impacts on the St. Paul District section of the project. Other technicians, such as assistant engineer James R. Johnson, junior engineer Elmer Christenson, assistant engineer Edward F. Brownell, assistant engineer Henry J. Manger, assistant engineer Leo M. Buhr, and assistant engineer George O. Guesmer, all received training at the University of Minnesota. Martin Nelson, assistant engineer in charge of hydraulic model studies conducted at the University of Iowa at Iowa City, was not only a graduate of the University of Minnesota engineering program; he

had also completed one year of postgraduate study of hydroelectric practice at the Royal Technological Institute at Stockholm, Sweden, under a scholarship given for outstanding academic performance. Since the designs of the Roller gates used in the 9-Foot channel's movable dam system had been invented in Sweden, it is only reasonable to assume that Nelson's expertise was a welcomed asset in the St. Paul District's administration of the channelization program.[19]

General engineering and architectural system designs were initially handled by the St. Louis U.M.V.D. office and the staff of engineer William McAlpine. A graduate of Massachusetts Institute of Technology (1896), McAlpine constituted the nation's expert in river improvement and flood control. McAlpine served as Head Engineer in the Division Engineer Office at St. Louis from 1929 to 1933. In that year, he transferred to Washington, D. C., where he headed the Engineering Section of the Office of the Chief of Engineers. According to one historian, McAlpine had in his employ a number of German draftsmen. These draftsmen kept busy translating meters into feet for the American engineers regarding the prototypical Scandinavian and German technologies on which the Mississippi complexes were based. However, some district offices were responsible for specific design considerations themselves. Rock Island District personnel documents reflects numbers of such employees. According to historian Roald Tweet, design for all locks and two dams (15 and 20) were accomplished at the U.M.V.D. offices in St. Louis. Designs for the remaining dams were left to the individual districts in which they were located. Projects were divided into "A" and "B" categories, depending on the urgency of their design and implementation within the context of the overall system.[20]

Actual construction of Locks and Dams 3-9 in the Corps of Engineers' St. Paul District began in 1930. Funding was initially supplied by emergency relief sources until 1935, at which time Congress appropriated monies for the completion of the project. The project's initiation during the nation's greatest economic depression affected the program in a number of ways. One of the most noticeable was the preoccupation of the Corps with safety standards on the construction sites. With the involvement of the Economic Recovery Act and related programs, numbers of untrained laborers found themselves at work on the locks and dams. Employment peaked in 1934 in the St. Paul District, when over 5,000 government and private construction employees were at work on the project. A special periodical, Old Man River, was published monthly by the St. Paul District in an effort to not only keep all personnel abreast of the various project developments, but also, as advertised in its own sub-banner, ". . . to promote safety among District and Contractor's employees. . . ." Charts were regularly printed, noting the number of accidents at each lock and dam project, the number of man-hours lost to accidents, and other pertinent data. Deaths were not uncommon during the course of construction. Between November 30, 1934, and December 31, 1937, eleven lives were lost in construction-related accidents. According to reports, efforts were made to inform workmen of safe construction practices through classes in which foremen and field men alike participated in

demonstrations of safety equipment, such as hardhats, safety shoes, and items of particular importance to river workmen such as kapok life vests. As the projects neared completion, concern over safety did not diminish. Bulletins establishing safety procedures for lock and dam operations and district safety meetings and tours of facilities continued to be items regularly addressed by memorandum and publication. Specific safety regulations were the purview of the individual district offices including visitation at construction sites.[21]

In addition to concerns with safety, documentation of the project proved to be of particular concern, reaching gigantic proportions with thousands of maps, drawings, and records being produced in the course of 10 years' work. Records held by various National Archives regional depositories contain a staggering number of files and boxes. The Chicago collection of Record Group 77 contains hundreds of linear feet of material alone. Included are detailed engineer logs documenting the erection and assembly of the complexes, weather conditions affecting work, and all other pertinent data relative to the project's successful prosecution. In addition, current records are also kept by the St. Paul District, involving thousands of maps, drawings, and photographs. Unaccessioned records have also been recently discovered at individual lock and dam sites as well.

The St. Paul District took documentation one step further in July 1035, with the purchase of a 16 millimeter Cine Kodak Special motion picture camera. Two 400-foot reels were produced entitled "Mississippi 9-Foot Channel Project." General in nature, about one-fourth of the content was devoted to navigation questions, according to contemporary accounts. The picture was shown so often and received so favorably that an additional project of greater scope was attempted: two additional reels, one devoted to technical questions for engineering schools, the other for lay audiences. According to Channel News, 18,800 feet of film were shot and developed on 100-foot reels with 15,600 feet relating to actual lock and dam construction. This raw material was to be edited into twelve 400-foot reels, with running time of approximately 15 minutes. Films of 4,800 feet were made for technical audiences; 2,400-foot films were assembled for non-technical viewing. The sophisticated process involved titles, animated pictures, and graphs. At the time of the article in the Channel News, plans were being made to combine old materials with new information on clearing operations and would ultimately involve two 400-foot reels of film. At least one of the films has survived. Its existence was confirmed by the St. Paul Office in 1987 as part of the district office records.[22]

By 1940, eight complexes were substantially complete, with the exception of some ancillary service elements such as lockkeepers' dwellings, garages, and access roads. Lock and Dam 10 at Guttenberg, Iowa, originally constructed under the supervision of the Rock Island District, was transferred to the St. Paul District on October 1, 1939, making a total of nine complexes under the jurisdiction of the St. Paul District as a result of the 9-Foot Channel Project.[23]

The 9-Foot Channel Program benefited those communities located in the Upper Mississippi River Valley with improved waste treatment for municipalities and additional recreational opportunities. But, most notably, commercial tonnage capacity on the Mississippi River dramatically increased. From the beginning of the project, the goal of increased commercial river transportation transcended other considerations. Gen. Markham of the Corps of Engineers, in a speech given at the dedication of Lock and Dam 4 at Alma, Wisconsin, in 1935 reflected the changed mood of the Corps from the time of Maj. Gen. Jadwin's opposition a scant five years before:

> The Mississippi River system, when completed, will connect the industrial East, centered around Pittsburgh, with the enormous granary of the Missouri Basin, the agricultural regions of the Upper Mississippi, the factories and mills of the Twin Cities, with the great Port of New Orleans as a shipping point to the ports of the world.1 The system includes the Ohio River system with 3,000 miles of improved channel serving 7 states; the Illinois River system, with 400 miles of improved channels serving 2 states; the Upper Mississippi, with 650 miles of improved channels serving 5 states; the Missouri, with 500 miles of improved channels serving 4 states; as well as the Tennessee, Cumberland and Lower Mississippi Rivers brings to a hinterland in excess of one million square miles, the benefits which must inevitably result, from dependable water transportation.[24]

Business and politics had been well served. Total tonnage of commodities moved on the Upper Mississippi River in the St. Paul District in the 1938 season exceeded 1/2 million tons--two times the tonnage noted for the same river area in 1937. According to one source, river traffic increased from 2,400,000 tons in 1939 to 68,400,000 in 1976. Since completion of the system in 1940, commerce on the Upper Mississippi increased from 0.5 to approximately 3.17 percent of all United States shipping.[25]

The Upper Mississippi River 9-Foot Project thus represents change on a variety of fronts--in political as well as business philosophies. What began as a regional manifestation of Progressive politics and business lobbies ended in a gigantic public works project managed under the unlikely aegis of the U. S. Army Corps of Engineers. Ultimately benefiting the nation at large, its impact on the environment of the Upper Mississippi Valley remains its only questionable legacy.

HISTORY OF TECHNOLOGY

The Upper Mississippi 9-Foot Channel Project reflected not only change in politics and business, it mirrored important changes and developments in engineering design and technology as well. The 26-unit Upper Mississippi 9-Foot Channel Lock and Dam System, as represented by Complexes 3-10 in the St. Paul District evidences these specific engineering innovations and

developments. When viewed as integral parts of a total working unit, they comprise an important section of a significant engineering resource reflecting the evolution of river hydrotechnology and hydrology in the United States. Building on prior European and American design contributions, research provided as a result of the 9-Foot Channel Project enabled the development of submersible gate and elliptical Tainter gate systems, making the earlier Roller/Tainter gate combination systems obsolete by the project's completion. Thus, these systems have particular significance, as they are no longer designed or constructed due to technological advances resulting from research incidental to their own development and construction.

The 9-foot channelization of the Upper Mississippi River required the design and construction of a lock and dam system. In section, the system resembles a water stairway with each lock and dam situated higher than the one before it, as it ascends the Mississippi from St. Louis to Minneapolis. Thus, instead of the river channel becoming more shallow as one moves upriver, a 9-foot channel is regularly maintained from lock to lock, enabling commercial barges and tows to use the river without having to transfer cargoes to smaller and smaller barges as they proceed upriver. To move from a lower elevation to a higher one, or vice versa, a tow and barge must enter the lock. Water is then added or deleted, bringing the boats to the desired level. The barges then proceed across the slackwater pool to the next complex, where the process is repeated. Movable dam systems regulate the waters pooled in the river, ensuring enough water for navigation, while at the same time guarding against flooding at high water periods.

In general, the standard configuration for any given lock and dam site in the St. Paul District section of the Upper Mississippi 9-Foot Channel Project included four basic components: a movable dam structure comprised of both Roller and Tainter gates equipped with dikes, spillways, submersible dams, and other auxiliary installations as needed to facilitate efficient and safe operation provided the central element of each system. A 110 by 600 foot lock, with electrically-operated miter gates and a gravity-fill system with water ingress and egress accomplished through tunnels underneath the lock, provided access from one side of the dam to the other. Foundations for future auxiliary locks with standard dimensions of 100 by 269 feet enabled the flexibility for future expansion of any given complex. Various esplanades, lockkeepers' and assistant lockkeepers' dwellings, main control stations, stage recorder houses, garages, and other necessary outbuildings, dictated by the needs of each site, completed a typical lock and dam site. Each installation, although having common standardized components, was uniquely designed for its particular location and function, thus creating a complementary engineering system of related units.[26]

General system designs evolved from previous Corps experience with canalization of the Ohio River, beginning in 1874, when Col. William E. Merrill of the U. S. Army Corps of Engineers recommended the construction of a series of movable dams and locks for the improvement of navigation on the Ohio River. The

systems called for a standard lock size of 110 by 600 feet and movable dam system with wickets or gates based on designs originally conceived by Frenchman Jacques Chanoine in 1852. The construction of the Davis Lock and Dam in 1885 represented the first movable dam built in the United States. Improvements on the Ohio River system continued over the years, resulting in the construction of over 50 lock and dam installations. During the initial stages of the Upper Mississippi 9-Foot Channel Project, the final stage of completion for the 9-foot channel project on the Ohio River was just coming to a close.[27]

The standard lock size used in the Ohio River project was well suited to the needs of the Upper Mississippi River channelization; the Chanoine wicket and rolling gates of the locks were not. Heavy ice flow (12 to 24 inches), shallow channels, water oxygen levels, and fish migration were only a few of the problems that could not be accommodated through the use of Chanoine dams, a complex system relying on intricate movable gates and props. Ice also promised to be a problem for the rolling gates of the Ohio lock systems. Unique flooding problems required special considerations. Most of the proposed lock and dam sites were located in low-lying areas where maintenance of water levels were crucial. Water levels could not be raised more than 12 inches above the natural flood level lest abutting rail lines, farmlands, and communities be inundated by pooled waters. The need for a different type of movable low dam system and lock gate became readily apparent. American engineering solutions to these problems resulted in the adoption of an innovative system designed for both heavy ice flow and low dam environments.[28]

The most notable design features to evolve from the Upper Mississippi River system involved the design of movable dams comprised of both Roller and Tainter gates to accommodate these special needs and to control the river's hydromechanics. French engineering technology provided inspiration for American pioneer engineers on the Ohio River in the 1870s. Scandinavian and German technologies now provided similar inspiration to the engineers of the Upper Mississippi 9-Foot Channel Project. Roller gates, developed in Scandinavia by M. Karstanjen at the turn of the century and patented in Germany by the Krupp and M.A.N. Corporations, were specified for the project due to their successful European application in heavy ice flow and debris conditions. Their capacities, economy of construction, and non-obstructive properties were seen as particularly desirable for the Upper Mississippi project. Roller gates, consisting of large cylinders equipped with gears located at each end of the drum, meshed with an incline track attached to the concrete piers on either end of the unit. The cylinder drum raised and lowered by a special chain mechanism wrapped around one end of the drum. Hoist machinery functioned in fixed installations above each gate.[29]

The peculiar environment of the Upper Mississippi required modifications to the original Roller gate designs. For example, in the case of Dams 3 and 9, roller gates were designed to be submersible for 5 feet, so that the heaviest loads of ice could pass through, instead of adopting the usual system of

raising the gate from the sill. Flap type Roller gates were also discussed for use in the configuration in Dam 4 for overflow purposes in the initial stages of designs for the project. Such innovation in gate design was a special feature dictated by the environment in which the systems were placed. According to specialists attached to the project, "The unusual conditions under which the Mississippi River dams must operate with respect to ice discharge, accurate pool regulation and navigable currents in the lock approaches, have led designing engineers to tax their ingenuity in designing suitable spillway gates. Many unprecedented features have been developed in Roller and Tainter gates, the submergible types in particular, as required by the demands of operation." All Roller gates had a damming height of 20 feet and, with the exception of Dams 4 nd 5, were 80 feet in length. Roller gates at Dams 4 and 5 were 60 feet in length.[30]

The importance of German engineering technology on the 9-Foot Channel Project was not lost on American engineers. Lt. Col. P. S. Reinecke noted parallels between the Mississippi and the Rhine regarding commercial navigation in an article entitled "The Rhine and the Upper Mississippi," published in The Military Engineer (May-June 1938). Similarities and differences in the two "regulated river' projects were called out, including the advances made in American technology. Specific references were noted regarding the development of American Tainter gate technology and its superior design qualities in relationship to German Roller gate designs. The article ended with a positive economic note for the concept of regulated rivers: "After considering the example of the Rhine . . . it is reasonable to forecast in a highly successful and satisfactory development of navigation along the Upper Mississippi in a few years."[31]

The development of Roller gates particularly suited to the Upper Mississippi required constant communication between Corps officials and the various companies involved in the manufacture of the gates and related machinery. At a meeting held at the Milwaukee plant of the Allis-Chalmers Manufacturing Company on January 8, 1934, between representatives of the U. S. Engineering Offices at St. Louis and St. Paul, the M. H. Tredwell Company of New York, and representatives of Allis-Chalmers, certain orders of procedure were established for the review, approval, and transmittal of plans and computations to the various contractors and government offices, so that delays would be minimal. Corporations such as McClintic Marshall Corporation in Chicago, Illinois, involved in specialized aspects of manufacture, were also included in the continuing dialogue involving every possible detail of Roller gate design. At the first indication of problems, a flurry of correspondence triggered both Corps and private engineers to find solutions. Typical problems involved such items as discrepancies in interior bracing in the drum assemblies and details in end shields requiring adjustments, or 10-degree changes in pressure angle designs for rack and spur rim teeth "in order to obtain more teeth in section and avoid a sudden transfer of load from one tooth to another." A 10-degree pressure angle change would provide for 1.4 teeth in section and would improve the design by "decreasing the separating force that tends to move the drum

upstream from the right." These and countless other similar details had to be resolved accurately on a day-to-day basis, in order for the leviathan-like project to proceed.[32]

Tainter gates, the second major element of the movable dam system, completed the basic movable dam technology. These gates, developed in the United States by Wisconsin lumberman Theodore Parker and patented by Jeremiah B. Tainter in 1886, consisted of a section of cylinder controlled at both ends by armatures operating on pins attached to the supporting piers. The gates lifted by one of two methods, both using chain hoists. In the first method, the system opened and closed by a hoist traveling on rails on an oversized service bridge designed to accommodate the hoist car. In the second method, the gates operated by a line shaft and motors instead of the movable hoist system. Locking systems held the gate at the necessary point. Both methods were used in the Upper Mississippi project. Two complexes used hoist car systems in conjunction with Tainter gate designs. As in the case of the Roller gates, modifications to Tainter gate designs allowed certain units to be submerged during heavy ice flow and debris conditions.[33]

The combination Roller and Tainter gate dam seemed ideally suited to the particular needs of the project. However, contemporary experts in the field of movable dam construction such as Ing. Dr. Techn. Armin Schlkltisch in his 1937 work, Hydraulic Structures, stated that combination systems should never employ more than two types of regulators (gates), and that "water level(s) can be regulated and the debris deposits sluiced out more effectively if all the regulators are alike, while the emergency closure can be accomplished with simpler and cheaper means." The decision to use more than one type of regulator in any given dam was, according to Schokltisch, "essentially a matter of cost." Technical problems in combination systems were noted as being "absolute operating reliability" and the capacity for the removal of ice and wood debris. Schokltisch stated that Roller gates were more advisable when riverbed load was large, Tainter gates being noted as being more efficient in small bed load situations. Army engineers, however, adopted the combination gate concept for the same reason that Schokltisch advised against it--to accommodate the need for an exact regulation of flood stage variables. Again, the Upper Mississippi River had dictated a change in engineering philosophies. Numbers and configurations of Roller and Tainter gates varied from site to site as needed. The system supplied the necessary flexibility and worked to the advantage of the project's operation. The unique properties of the movable dam concept complemented the equally unique environments of the Upper Mississippi.[34]

The 9-Foot Channel Project resulted in many innovations, particularly in matters of gate design. Tainter gates, with an average width of 35 feet for more applications, soon evolved into unprecedented lengths of 60 feet in some project locations. Eventually, Lock and Dam 24 employed Tainter gates 80 feet in length, as well as design improvements in gate shape and the use of high tensile steel, based on those technologies developed in the early years of the

Upper Mississippi project. The final development of the elliptical Tainter gate in the latter years of the project owed its development to experiments in submersible and overflow gate technology in the Upper Mississippi project. Those experiments evolved, to quote one Corps officer, "by modification of the previously-designed non-overflow type just as the first automobiles were made by putting an engine in the conventional horsedrawn buggy."[35]

Similar advances were made in the area of Roller gate construction. The submersible gates were also noted in period publications as being unprecedented. Previously, Roller gate designs had not allowed submersible functions due to float and similar problems. Innovative engineering designs solved these difficulties.

The Upper Mississippi River combination gate movable dam system grew from the ingenuity of Midwestern engineers. This unique Roller/Tainter gate combination system has been cited in one study as one of the first known applications of its kind in the United States. As mentioned earlier, working models for these designs were handled in part for the St. Paul District at the University of Iowa at Iowa City by Civilian Corps engineer Martin E. Nelson. Nelson is noted in personnel reports as having had previous training in hydroelectric practice in Scandinavia. His working models answered important questions concerning foundation stability, ice discharge, accurate pool levels, navigation currents, and related matters.[36]

Many construction contingencies required advanced planning and consideration, not the least of which was the need for metals with anti-corrosion properties for use in construction of the locks and dams. The amounts required reflected the gigantic proportions of the project. Approximately 198,400 pounds of nickel steel and 5,700 pounds of nickel chromium steel were used in the construction of Lock and Dams 4 and 5 alone.[37]

Like their movable dam counterparts, the lock systems also contain notable features. Problems with ice and sediment had caused malfunctions in Roller-type lock gates on the Ohio River and encouraged engineers to develop a new gate system. By 1912, miter gates had been developed on the Ohio River, a mechanism consisting of two hinged panels that, when closed, form a miter point or "V" configuration pointing upriver. Corps engineers concluded that miter gates would better serve the Upper Mississippi environment.

A Tainter-type lock valve configuration also replaced earlier Roller valve designs developed in conjunction with the 19th century Ohio River projects. The Tainter valve was noted as "somewhat unusual" at the time of its installation by virtue of its design and placement in lock wall wells to control the flowage of water into the lock chamber. Also, the concept of the auxiliary locks and the establishment of foundations for their future construction were noted as being exceptional for an inland waterway project. None of the auxiliary locks in the St. Paul District, however, were ever made operational.[38]

Foundation locations for the Lock and Dam Systems 3 through 10 lacked the necessary stability for construction purposes, thus requiring innovative and unprecedented solutions. Corps experts were immediately brought in from a variety of offices for consultation, including W. A. McAlpine of the U.M.V.D. office in St. Louis and R. R. Philippe of the Zanesville Laboratory, Zanesville, Ohio. Unlike the earlier sites at St. Anthony Falls, Minnesota, where substrata of sandstone and limestone enabled unshored methods of construction, the lock and dam sites at 3-10 required concrete foundations set on pilings to provide necessary stability. Such "depArtures from ancient precepts" in piling configurations required exact calculations. In one case, the dam substrate was entirely replaced with a more stable type of river sand to accommodate the driving of the necessary underpinnings. Testing for the project was accomplished at various testing centers, including the University of Iowa, the Soils Laboratory at the District Engineers office at Zanesville, Ohio, as well as the Fountain City, Wisconsin, laboratory of the St. Paul District office. "Photoelastic" models used by the Zanesville office, in which the unstable plastic strata was simulated by a gelatin element to pinpoint the difficulties related to stable foundation design, is one example of the sophisticated technologies brought to bear as the final stages of the St. Paul section of the project came to a close in the late 1930s.[39]

Other technologies, new to such construction, were implemented at various sites during the course of the project. Type "Z" piling, a type of steel piling first rolled some two years before the beginning of the Upper Mississippi project, represented the first use of this material in the St. Paul District and one of the earliest applications anywhere by the Corps of Engineers. The design of the piling made it useful in situations calling for maximum resistance to buckling or bending. These properties caused the Corps to specify the material for use in the construction of the dam abutments for Dam 3 instead of the more traditional methods of concrete gravity or reinforced counterfort sections. The name "Z" was taken from the shape of the piling. When one pile interlocked with another or a group of such materials, the result placed the maximum amount of metal away from the neutral axis. Such a configuration gave great strength to the construction. Also, the design of the curved portion of the abutment was felt to be unique at the time of its construction. The use of tie rods was deemed undesirable, so that "bulging" (radial pressure at the fill of the curves) would be curtailed, three tension bands were used at varying elevations. These heavy plates were augmented by three lighter plates to ensure additional strength. One end of the outer plates was anchored in concrete. The plate then followed around the exterior of the abutment. Connection to the outer end of the plate was followed along the straight section of the abutment and welded to the "Z" piles. The tendency for outward movement of the pilings at the corner was deflected by the "wrapping action" (circumferential tension) in the steel plating. This method of engineering and construction was noted as an unusual application of "Z" piling and was observed with great interest by those involved in the process.[40]

Testing for the "Z" piling experiment reflected the uniqueness of the Upper Mississippi project in general. St. Paul District engineer W. Z. Lidicker called attention to the tests and their innovative properties, drafting a paper entitled "Unusual Timber and Steel Bearing Pile Load Tests At Mississippi River Dam No. 3" in July 1935. The article contained a detailed account of the "unique treatment of a difficult foundation problem" at Dam 3. In these cases, according to Lidicker, timber pile tests "gave an opportunity to study the variation of indicated bearing value with length of piles and spacing (or compaction) in sand foundations," while steel piling tests gave "information . . . on the actual bearing value of ten feet penetration into sand at a considerable depth below the surface." A detailed technical account followed the 13-page report. The proposed article caused much comment among various officers in the Corps of Engineers. Lidicker also assembled another technical paper involving soil loading tests on buried tie plates. Since, according to Lidicker, the technical literature of the time contained little information on the subject, a series of tests were developed by Lidicker and H. M. Hill, Senior Engineer at the St. Paul office, to assess the problem of extreme lateral stress and loading due to settlement.[41]

The development of specialized testing criteria proved to be of particular importance to the Upper Mississippi project and soon became routine. Testing for the project was a daily occurrence with every conceivable element of the project constantly receiving expert scrutiny. Many such tests provided valuable research that formed the basis for future improvements. When tests of critical importance were not available in contemporary literature, Corps personnel developed their own. In some cases, as in the testing of substrate stability for the Lock and Dam 3 foundations, the ultimate decision to remove the unstable silt layer corrected the problem and rendered the testing results moot. Other attempts in experimentation failed entirely, as in the case of the attempt to design an auger with specially-designed flaps for the retrieval of soil samples from beneath the riverbed. Nevertheless, their contribution to the body of knowledge remained important.

Positive results quickly evolved from the continuing research and testing process. For example, experimentation in cofferdam design in relation to seepage at Dam 6 by the St. Paul District and elsewhere enabled advances to be made in cell design and configuration as well as pumping methodologies for future projects. Because of the special substrate conditions, Lock and Dam 3 provided the impetus for many tests which included everything from trial concrete mixes to tests for probe resistance and soil density. Other testing included load, pile, and paint tests, as well as tests for concrete temperature. Related information gained from earlier projects, such as the concrete testing done at the Huntington District's London Lock and Dam on the Kanawha River in West Virginia, also helped engineers in their pursuit of elusive data and computation of probable effects of construction.[42]

New technologies also resulted from the project's construction. For example, a new type of skid pile driver was built on the job site by general contractors, Spencer, White and Prentis of New York City, and used in the construction of Lock and Dam 6. Vulcan Number One steam hammers equipped the installations used in pile driving for the lock structure, steam power being provided by the C. B. and Q. Railroad at $5.00 per day. A new method of keeping the pile hammers level, developed by the project contractor, based on a circular steel slot bolted and welded to the hammer's side, proved effective in driving the piles and sheets plumb, thus eliminating the need for the usual guide lines. Contractors also entered the testing realm when necessary. The president of Spencer, White and Prentis and consultant, Lazarus White, constructed a model of the lock cofferdams at 1:24 scale to determine actual pumping needs. According to the construction history, "the effect of berm and ditches and the relation between depths of sump and elevation of water were clearly demonstrated by the model and the results and information obtained many times justified its cost."[43]

According to Lt. Col. Malcom Elliott, technologies evolved so quickly during the course of the 9-Foot Channel Project that new ideas and concepts were constantly reflected in the structures. The result was that earlier structures became partially outmoded as the final installations were completed. The evolution of innovative construction and design manifested itself in the series of lock and dam complexes from the beginning to the end of the project. Earlier design precedents on which later engineering innovations were based formed the 658-mile system known as the 9-Foot Channel Project for the Mississippi River. As noted by Corps historian, Dr. John Anfinson, the system was only as strong as its weakest link--all installations had to be specifically designed to function as a member of a 26-unit canal system, while at the same time accommodating local geographic and hydrographic pecularities. Thus, a unique construction document developed as the construction progressed, imbedding itself in the concrete and steel of the lock and dam system.[44]

As in the case of engineering, architectural design work evolved over the 10-year project period. As a result, two distinct architectural styles can be observed, those constructed before and after 1936. Responsibility for the design of the gates, piers, and other structures at Locks and Dams 3 (1938) and 4 (1935) is unable to be determined at this time. At least one source notes the participation of an unnamed consulting architect. Construction of Lock and Dam 5 (1935) is referenced in at least one publication as having been supervised by the St. Paul District, with, it is assumed, design work being handled by other offices. Information on Lock and Dam 5A (1936) is not available; however, construction of Lock and Dam 6 (1936) was again supervised by the St. Paul District, with design work accomplished elsewhere. Locks and Dams 7 (1937), 8 (1937), and 9 (1938) are noted as having two distinct administrative components. Construction of locks was supervised by the St. Paul District. Dams were designed and construction supervised by the district offices as well.

The pre-1936 designs, evidenced by Locks and Dams 4 (1935), 5 (1935), and 6 (1936), are relatively ungainly, the Roller gate piers having buttress detailing, large, industrial sash windows, and metal hipped roofs with six-sided machinery housing units perched atop individual oval pier units. The Tainter gate piers tend to be more simple and direct. Designs occurring during and after 1936 (Locks and Dams 3, 1938; 5A, 1936; 7, 1937; 8, 1937; 9, 1938; and 10, 1936) are more standardized and sophisticated, having streamlined detailing and taller pier bodies with machinery housing units incorporated into the overall pier design. Some designs accomplished after 1036 incorporated arch detailing in conjunction with Tainter gate pier design.

The year 1936 would seem to be a year of transition. Design of the Roller gate piers changed drastically from that date. Lock and Dam 6, finished as of August 20, 1936, was of the earlier, more ungainly variety. However, Locks and Dams 5A and 10, finished on July 6, 1936, and December 10, 1936, respectively, were of the more streamlined genre. Clearly, two separate design philosophies were being used. The evolutionary nature of the design history is further evidence in the early designs of Tainter gate piers for Lock and Dam 4 (1935) and their various permutations, most notably surfacing in the construction of Lock and Dam 2 on a much larger scale in 1948, 13 years after the design's original employment.[45]

Just as the 9-Foot Channel Project owned much of its success to its status as a child of the Depression, so the change in architectural designs owed their evolution to the same era. The Century of Progress Exhibition, held in Chicago in 1933, focused on national and international advances in technology and engineering. These currents may have effected the change in design considerations, especially when viewed in the light of the German Roller gate designs and outright comparisons of the Upper Mississippi and the Rhine by Corps personnel. The Corps of Engineers participated in the Exposition's engineering symposia which included experts from all over the world. A "joint engineering luncheon" was sponsored by the American Society of American Engineers in honor of U. S. Army Corps Chief of Engineers Gen. Lytle Brown, as part of the Exposition's scheduled events. The message of the modern in architecture evidenced itself in the chapter of the Exposition's official guidebook entitled "The Symbol of Arcturus." Certain passages are reminiscent of the post-1936 lock and dam pier design and the reduction in window size and overall streamlining: "Consider the architecture of the buildings. Wonder, perhaps, that in most of them there are no windows. Note curiously that these structures are for the most part unbroken planes and surfaces of asbestos and gypsum board. . . ." The brochure noted the fair's architecture and planning as elements of a "huge experimental laboratory" designed to further modern concepts in both fields. The Corps heeded the message of the Exposition, as the Upper Mississippi project moved forward.

The Century of Progress Exposition reflected the general mood of American engineers and architects. The promoters of the Tennessee Valley Authority (TVA) summed up the concerns of engineers-designers involved in that

contemporary project: "Because the engineer, like the architect and artist, has a strongly disciplined sense of order, and because the purely functional is generally esthetically satisfying, these dams and their adjuncts are overwhelmingly beautiful. . . . Such objects . . . make up a new grammar of design which cannot be disregarded by the architect." David Lilieanthal, speaking again of TVA, stated that "we want those dams to have the honest beauty of a fine tool, for TVA was a tool to do a job for men in a democracy." The same thoughts applied to the locks and dams system on the Upper Mississippi.

As the Upper Mississippi 9-Foot Channel Project neared completion, the 1939 World's Fair in New York again focused on technology with its symbols of the perisphere and trylon, but this time without German participation. Nevertheless, the Depression-era message of the modern had not been lost on the American lock and dam designers. It had manifested itself in the concrete and steel of the post-1936 complexes.

Designs for lockkeepers' and assistant lockkeepers' residences, esplanades, control stations, and other ancillary buildings were simple and utilitarian, borrowing from Colonial and Georgian examples closer to home than the austere, monolithic concrete designs of the gate piers. Some control stations were equipped with neoclassical arched windows and simple detailing. In all cases, simplicity continued to be the hallmark of all general design considerations.[46]

SUMMARY

An important chapter in the evolution of United States hydroengineering history is reflected in Locks and Dams 3-10 of the Upper Mississippi 9-Foot Channel Project. Its significance lies in its evolutionary nature, reflecting rapid changes in technology during the 10-year project, from Tainter/Roller gate dam system to elliptical Tainter weir systems. Building on prior European and American design contributions, research provided as a result of the 9-Foot Channel Project enabled the development of submersible gate and elliptical Tainter gate systems, making the earlier Tainter/Roller gate combination systems obsolete by the project's completion.

The final obsolence of the Roller dam system, made possible by advanced Tainter gate designs, was a logical progression in river hydrotechnology, in much the same manner as Roller dams replaced Chanoine wicket systems on the Ohio River in the 1930s. Thus, many of these complexes have a particular significance, as they are no longer designed or constructed, due to those technological advances reflected in the systems' own unique evolutionary designs.

The work carried on by the St. Paul District at the University of Iowa testing laboratories and the research of civilian engineers, such as Hibbert Hill and Martin Nelson, contributed significantly to the overall 9-Foot Channel Project in matters of gate technology and general dam design. Testing in areas, such

as foundation stability by technicians such as E. J. Christenson and W. W. Ralphe and their work on Lock and Dam 3, resulted in the use of new materials, techniques, and innovative applications, providing the basis for future progressive engineering designs. These innovations and other like them resulted in such later developments as the 80-foot Tainter gates located at Clarksville, Missouri, in the Rock Island District and the 125-foot Tainter gates on the Ohio River at Gallipolis, among the largest installations of their kind ever built in the United States.

Other developments, such as the creation of independent hoist machinery for Tainter gate functions and the elimination of hoist cars, are physically reflected in the St. Paul locks and dams system, as are the engineering and architectural design philosophies of the district and division offices involved at the various stages of the project.[47]

The Upper Mississippi River 9-foot Channel locks and dams combination system of singular, specially-designed installations created a truly unique engineering entity. Locks and Dams 3-10, located in the St. Paul District of the Corps of Engineers, reflect a substantial portion of this important engineering project.

NOTES

[1]William J. Hull and Robert W. Hull, The Origin of the Waterways Policy of the United States (Washington, D.C.: National Waterways Conference, 1967), pp. 31-37.

Navigation concerns influenced river improvements even before the concept of a 9-foot channel. Originally built as part of a 5-foot channel concept, Lock and Dam Number 1 (1894-1932) was modified under the 6-Foot Channel Project by the River and Harbor Act of 1907. A Special Board of Examination of the Mississippi between St. Paul and Minneapolis (1910) recommended a single dam would be more beneficial than two. Consequently, the lift at Lock and Dam Number 1 was increased from 13.3 feet to approximately 30 feet. (Later, the lift was increased again during the 9-Foot Channel Project.) As a result, Lock and Dam Number 2 (1907), in operation for 10 years prior to Lock and Dam Number 1, was removed. Ultimately, the lock and dam installation constructed at Hastings, Minnesota, became the Lock and Dam Number 2 of the 9-Foot Channelization Project (1927-1940). As noted by historian Jon Gjerde (p. 125), Lock and Dam Number 2 represents an engineering and historical link between Lock and Dam Number 1 and the later 9-Foot Channel Project. The upper and lower locks located at St. Anthony Falls at Minneapolis/St. Paul were built as later construction projects in 1963 and 1956 respectively, each having their own particular function and place in the overall project system. For a more complete discussion of the various periods and alterations prior to the 9-Foot Channel Project regarding the lock and dam system see Jon Gjerde's work "Historical Resources Evaluation: St. Paul Locks and Dams On the Mississippi River and Two Structures At St. Anthony Falls," (St. Paul District, U.S. Army Corps of Engineers, 1983), pp. 118-128; 161-179.

[2]Patrick James Burnet, "The Corps of Engineers and Navigation Improvments on the Channel of [the] Upper Mississippi River to 1939" (Master's Thesis: University of Texas at Austin, August 1977), p. 88.

[3]Raymond H. Merritt, The Corps, the Environment and the Upper Mississippi Basin (Washington, D.C.: Government Printing Office, 1984), pp. 53-63; Burnet, "The Corps of Engineers and Navigation Improvement on the Channel of [the] Upper Mississippi River to 1939" p. 88.

U.S. Army Corps of Engineers, St. Paul District, "Improvement of the Upper Mississippi River, Missouri River to Minneapolis, Minnesota: A Review of the Project, Its Purpose, Progress Made on Construction, and Objectives and Benefits," n.d., typewritten, p. 10; H.M. Anderly to Alfred Rice, 6 December 1940, Record Group 77, subgroup: St. Paul District, General Records 1934-1943, Box 39, Entry 1629, File 4013.1/1-4013.1/134, 4013.1/28-11 to 4013.1/65.16, National Archives, Kansas City Branch, Kansas City, Missouri (hereafter referred to as NAKCB).

[4]Col. Philip B. Fleming, interview by Mary Proal Lindeke of WMIN Radio Station, "Talking Things Over" 12 January 1939, 11:45 a.m., radio script; "The Upper Mississippi River Nine Foot Channel," pp. 5-6, Record Group 77, subgroup: St. Paul District, General Records 1934-1943, Box 18, Entry 1629, File 46.1, NAKCB; The Corps, the Environment and the Upper Mississippi Basin, pp. 53-63.

Robert M. LaFollette, Jr. to the Honorable George H. Dern, Secretary of War 16 April 1936; Harry H. Woodring, Acting Secretary of War, to the Honorable Robert M. LaFollette, Jr., 18 June 1936; Colonel J.N. Hodges, Memo: Dam on Mississippi River near Diamond Bluff, Wisconsin, 3 June 1936 (3 pages); Marlin Craig, Acting Secretary of War to the Honorable Robert M. LaFollette, Jr., 1 May 1936, Record Group 77, subgroup: St. Paul District, Operations and Maintenance Files, 1931-1943, Box 395859, Entry Number 1626a, File 373.1, National Archives, Chicago Branch, Chicago, Illinois (hereafter referred to as NACB).

The Corps, the Enviroment and the Upper Mississippi Basin, p. 57; Roald D. Tweet, History of Transportation on the Upper Mississippi and Illinois Rivers, National Waterways Study: U.S. Army Resources Support Center--Institute for Water Resources--Navigation History NWS-83-6 (Washington, D.C.: GPO, 1983) p. 83.

House Document Number 290, 71st Congress, Second Session (photocopy); W.H. McAlpine, Head Engineer to District Engineer, U.S. Engineer Office, St. Paul, Minnesota, 16 August 1933 (attachments) p. 3, Record Group 77, subgroup: St Paul District-Operations and Maintenance Files, 1931-1943, Box 395861, Entry Number 1626a, File 413b.3/08-5, NACB.

Jon Gjerde, "Historical Resources Evaluation: St. Paul District Locks and Dams on the Mississippi River and Two Structures at St. Anthony Falls," (St. Paul District, U.S. Army Corps of Engineers, 1983), pp. 132-161.

[5]Raymond H. Merritt, Creativity, Conflict and Controversy: A History of the St. Paul District U.S. Army Corps of Engineers (Washington, D.C.: GPO, 1979), pp. 187-214; "The Corps of Engineers and Navigation Improvement on the Channel of [the] Upper Mississippi River to 1939," pp. 96-97.

[6]"The Corps of Engineers and Navigation Improvement on the Channel of [the] Upper Mississippi River to 1939", pp. 96-97; Mary Yeater Rathbun, draft History of the Rock Island District, Chapter IV, "A New Attitude Towards Water Resources 1898-1921," p. 121, Chapter V, "Origins of the Reactivated District 1921-1937," p. 170 (photocopy).

[7]Creativity, Conflict and Controversy, p. 197; Maj. Gen. Edgar Jadwin, Chief of Engineers, U.S. Army Corps of Engineers, "River and Harbor Engineering in the United States" presented at the World Engineering Congress, Tokyo, Japan, (undated), Record Group 77, St. Louis District Office, General Correspondence, 1926-1940, Box 2, Entry 1686, File 1796/8, "River and Harbor Engineering in the U.S.," NAKCB.

8"The Corps of Engineers and Navigation Improvement on the Channel of [the] Upper Mississippi River to 1939," p. 96-103. Philip V. Scarpino, Great River: An Environmental History of the Upper Mississippi River 1890-1950 (Columbia, Missouri: University of Missouri Press, 1985), pp. 142-150.

[9]"The Corps of Engineers and Navigation Improvement on the Channel of [the] Upper Mississippi River to 1939" pp. 96-103. "Hearing To Be Held Soon On Alma Dam Project" The Winona Republican Herald, n.p. (photocopy); "Date Set for Hearing on Alma Dam: Walton League Heads to Meet Here," Winona Republican Herald, 6 February 1931, n.p. (photocopy); "Modify the Alma Dam" Wabasha County Herald Standard, Thursday 5 March 1931, p. 2. (photocopy).

[10]Lt. Col. Wildurr Willing, Maj. Glen E. Edgerton, H.W. McAlpine to Division Engineer, U.M.V.D. (Upper Mississippi Valley Division) St. Louis, 21 April 1931--Report: Public Hearing--Alma Dam, pp. 1-30, passim; W.H. McAlpine to Col. Wildurr Willing, 30 April 1931; Lt. Col. George R. Spalding to Chief of Engineers, Washington, D.C., 28 May 1931, p. 1-5; Lt. Col. Wildurr Willing, "Notice to the Press and Interested Parties," 3 August 1931; Transcript: Hearing at Wabasha, Minnesota, 26 February 1931 re: construction of dam at Alma, Wisconsin, pp. 1-31, Record Group 77, subgroup: St. Paul District, Operations and Maintenance Files, 1931-1943, Box 395861, Entry Number 1626a, File 413.b, NACB.

[11]House Document Number 290, 71st Congress, Second Session; Document No. 7, 72nd Congress, 1st Session, House of Representatives, Committee on Rivers and Harbors, "Mississippi River From Missouri River to Minneapolis--Decree of Injunction Restraining the Government From Construction of a Lock and Dam at Alma, Wis.," pp. 1 and 6, Record Group 77, subgroup: St. Paul District, Operations and Maintenance Files, 1931-1943, Box 395861, Entry Number 1626a, File 413b.3, NACB.

[12]Col. George R. Spalding to Chief of Engineers, U.S. Army, Washington, D.C., 24 March 1932; 72nd Congress, Public Resolution No. 10, H.J. Resolution 271 (typed copy); Memo: Modification of plans, Lock and Dam No. 4, Miss. River, in accordance with H.J. Res. 271; George R. Spalding to Chief of Engineers, 29 February 1932, pp. 1-4, Record Group 77, subgroup: St. Paul District, Operations and Maintenance Files, 1931-1943, Box 395861, Entry Number 1626a, File 413b.3, NACB.

[13]Maj. Gen. Lytle Brown, Chief of Engineers, Authority for Changes Lock and Dam 4 Alma, Wisconsin, 3 March 1932 (one page); Patrick Hurley, Secretary of War, to William Mitchell, Attorney General, 4 March 1932; William D. Mitchell, Attorney General, to Patrick J. Hurley, Secretary of War, 8 March 1932. Record Group 77, subgroup: St. Paul District, Operations and Maintenance Files, 1931-1943, Box 395861, Entry Number 1626a, File 413b.3, NACB.

[14]"Nine Foot Channel Seen As Menace to Wildlife," St. Paul Pioneer Press, 3 May 1934 (photocopy); Maj. Dwight F. Johns to Division Engineer, U.M.V.D., 5 May 1934 (memorandum), Record Group 77, subgroup: St. Paul District Box 395861, File 413b.3, NACB.

[15]John R. Foley to Maj. D.F. Johns, 16 October 1935; Harry H. Woodring, Secretary of War (acting) to Mr. Stanley D. Moore, 28 September 1935; S.B. Locke to Gen. Edward M. Markham, 21 September 1935; Stanley D. Moore to Honorable Harry H. Woodring, 25 July 1935; S.D. Moore to Dwight F. Johns, 5 August 1935; Maj. Dwight F. Johns to Mr. N.J. Tiedemann, 1 August 1935; Maj. R.A. Wheeler to Chief of Engineers, U.S. Army, Washington, D.C., 20 July 1935; N.J. Tiedemann to Hon. Harry H. Woodring, 24 June 1935; Col. Malcolm Elliott to District Engineers, U.S. Engineer Offices, Rock Island, Illinois and St. Paul, Minnesota, 18 November 1941 (memorandum: manuscript attached); Lt. Col. Philip B. Fleming to Capt. C.F. Culler, 5 December 1938; C.F. Culler to District Engineer, 28 November 1938; L.M. Buhr to Lt. Matheson, 5 July 1938 (memorandum), Record Group 77, St. Paul District, General Correspondence, 1934-1943, Box 39, Entry 1629, File 4013.1/28-11 to 4013.1/65, 4013.1/1-4013.1/134, NAKCB.

Maj. Gen. Schley, Chief of Engineers to Hon. Merlin Hull, 22 April 1939 (3 pages); H.J. Manger to Mr. H. Vansant, Senior Engineer, St. Paul, Minnesota, 23 April 1939 (3 pages), Record Group 77, subgroup: St. Paul District, Box 395861, File 413b.3, NACB.

[16]Confidential Memoranda: Presidential Inspection Trip, Lt. Col. Malcolm Elliot to U.S. Engineers Offices, St. Paul, Minnesota, Rock Island, Illinois, and St. Louis, Missouri, 30 June 1936; Capt. F.M. Albrecht, Memorandum-Inspection Trips: Check List for Inspection Trips by President, Secretary of War, Chief of Engineers, etc., 27 August 1936, pp. 1-3; Capt. E.C. Itschner, Confidential-Subject: President's Inspection Trip, 13 August 1936, pp. 1-2; Confidential-Subject: President's Inspection Trip: To the District Engineer U.S. Engineer Office, St. Paul, Minnesota, 13 August 1936. Correspondence re: President Roosevelt's Visit--Confidential File, Record Group 77, subgroup: St. Paul District, General Records 1934-1943, File 45.1/105, NAKCB.

[17]Creativity, Conflict and Controversy, pp. 190-203, 206-207, 437.

[18]Annual Authorities--Employees--District Engineer, St. Paul, Minnesota, through the Division Engineer, Western Division, 7 May 1929, pp. 1-20; Lt. Col. Wildurr Willing to Chief of Engineers 21 October 1929, re: Selection of Howard Anderly for Promotion; Gen. Lytle Brown, Chief of Engineers to the Secretary of War, 27 February 1930; Lt. Col. Wildurr Willing to The Chief of Engineers, U.S. Army, 13 February 1930. Memorandum: U.S. Engineer Office, St. Paul, Minnesota, 18 November 1929--Statement to accompany recommendation for increase of pay: Elmer J. Christenson, p. 2, Record Group 77, subgroup: St. Paul, Minnesota District: Box 8, Entry 1628, Miscellaneous Authorities, (FY 1930) Files 15/385-1 to 15/385-62, NAKCB.

U.S. Civil Service Commission Certificate No. 6425, 8 June 1927--Appointment of Elmer J. Christenson as Junior Civil Engineer; Arwood M. Miller, Civilian Personnel Officer to Chairman, Incentive Awards Committee, St. Paul District, CE, U.S. Army, Subject: Recommendation for Special Acts or Service Award, 1 March 1956 (3 pages), p. 3, U.S. Army, Corps of Engineers, Civilian Personnel-Personnel File: Elmer J. Christenson, Record Group 146 (unacessioned), Civilian Records Center, National Archives, St. Louis, Missouri (hereafter cited as NASL).

Christenson exemplified the quality of personnel recruited for the project. His work was cited by supervisors in March of 1956 as being exemplary--no sick leave was taken in that year and 178 hours of annual leave was sacrificed for the good of the program. Christenson was recommended for a $200-$300 award.

[19]Memorandum: Statement to accompany recommendation for increase in pay re: Hibbert M. Hill, U.S. Engineer Office, St. Paul, Minnesota, 13 February 1930, p. 2, Record Group 77, subgroup: St. Paul, Minnesota District: Miscellaneous Authorities, (FY 1930) Box 8, Entry 1628, File 15/385-1 to 15/385-62, NAKCB.

Memorandum-Subject: Survey of streams for navigation, flood control, power development and irrigation. U.S.E.O. St. Paul, Minnesota, 16 April 1928, p. 4; H.M. Hill, Engineer, to the Secretary, Federal Power Commission, Washington, D.C., 26 December 1930 (2 pages), p. 2; Personnel File: Hibbert M. Hill Record Group 146, U.S. Army, Corps of Engineers, Civilian Personnel (unacessioned), Civilian Records Center, NASL.

Memorandum: U.S. Engineering Office, St. Paul, Minnesota, 5 November 1929--Statement to accompany recommendation for increase of pay: James R. Johnson, p. 2; Memorandum: U.S. Engineer Office, St. Paul, Minnesota, 18 November 1929--Statement to accompany recommendation for increase of pay: Elmer J. Christenson, p. 2; U.S. Engineer Office, St Paul, Minnesota, 9 May 1930--Statement to accompany recommendation for increase of pay: Edward F. Brownell, p. 2; U.S.

Engineer Office, St. Paul, Minnesota, 9 May 1930--Statement to accompany recommendation for increase of pay: Henry J. Manger, p. 2; U.S. Engineer Office, St. Paul, Minnesota, 9 May 1930--Statement to accompany recommendation for increase in pay: Leo M. Buhr, p. 2; U.S. Engineer Office, St. Paul, Minnesota, 9 May 1930--Statement to accompany recommendation for increase of pay: George O. Guesmer, p. 2; Maj. Gen. Lytle Brown, Chief of Engineers to The Secretary of War re: Martin Nelson--Increase in compensation, 18 February 1930; Lt. Col. Wildur Willing to Chief of Engineers, U.S. Army--Subject: Increase of pay, Martin E. Nelson, Assistant Engineer, 4 February 1930; U.S. Engineer Office, St. Paul, Minnesota, 4 February 1930--Statement to accompany recommendation for increase in pay: Martin E. Nelson, p. 2; Record Group 77, subgroup: St. Paul, Minnesota District: Miscellaneous Authorities, (FY 1930) Box 8, Entry 1628, File 15/385-1 to 15/385-62, NAKCB.

Martin Nelson, Civil Service Commission, " Temporary Appointment, Transfer, Reinstatement or Promotion, Etc." 28 June 1938, p. 1-4; District Engineer, St. Paul District-Notification of Foreign Visit-Martin Nelson, U.S. Army Attache" (1 page) n.d. Personnel File: Martin E. Nelson, U.S. Army, Corps of Engineers, Civilian Personnel Record Group 146 (Unacessioned) Civilian Records Center, NASL.

Report on Economy in Expenditures in compliance with CIRCULAR LETTER (FINANCE NO. 173) Office, Chief of Engineers, 29 December 1932 and Letter from Division Engineer, U.M.V.D., 11 January 1933, Record Group 77, U.M.V.D., Organization Planning Files-Permanent #2, Box 9, Para 15-B, SR 345-250-5, NAKCB.

Martin Nelson, born 20 January 1898, grew to manhood in Grantsburg, Wisconsin. He went to work for the Corps of Engineers in 1929 with his appointment as an Assistant Engineer on the Lock and Dam project. His career spanned the decades between the 1930s and the post-World War II years. In 1964 Nelson was appointed Adviser to the Ministry of Public Works and Hydraulic Research and Experimental Station of the United Arab Republic, stationed at Cairo, Egypt.

[20]Rathbun Associates, "Historical-Architectural and Engineering Study, Locks and Dams 11-22, Nine Foot Navigation Project, Mississippi River, U.S. Army Corps of Engineers District, Rock Island, under Contract No. DACW25-84-C-0030, December 1985), two volumes: Vol. 1, p. II-23; U.S. Army Corps of Engineers, St. Paul District, "History of the Construction of Dam No. 5 Mississippi River 4.8 Miles Downstream from Minneiska, Minnesota" (Submitted by V.C. Funk, 31 January 1936), St. Paul District Office Records, St. Paul, Minnesota, p. 77.

Resume--William McAlpine (1 page); U.S. Civil Service Commission: William H. McAlpine, 28 December 1899; Statement for Approval of Transfer, Reinstatement, or Position Change, April 23, 1951 (#1 State of Qualifications and Experience, #2 Job Description); Qualification Summary- GS 16, 17, 18 (n.d., n.p.); Robert T. Stevens, Secretary of the Army to William H. McAlpine, June 17, 1954; Memorandum: Chief, Civilian Personnel Division, P&A, to Assistant Chief of Engineers for Military Operations, Subject: Security Clearance-Mr. William H. McAlpine, 10 August [19]51; Memorandum: Matthews to Chief, Civilian Personnel Division, Personnel and Administration, Subject: Security Clearance--Mr. William H. McAlpine 29 August 1951; Memorandum: S.D. Sturgis, Jr. Major General, USA, Chief of Engineers U.S.Army, Corps of Engineers, Subject: Commendation of Mr. William H. McAlpine MEMORANDUM FOR THE SECRETARY OF THE ARMY, 16 June 1954, Civilian Personnel--Personnel File: William H. McAlpine, Record Group 146 (Unacessioned) Civilian Records Center, NASL.

Telephone interview with Leland Johnson, Clio Research, Hermitage, Tennessee, 26 January 1987; History of Transportation on the Upper Mississippi and Illinois Rivers, p. 82.

The extraordinary career of William Horatio McAlpine as a civilian engineer attached to the U.S. Army Corps of Engineers covered over 50 years. Born at Lawrence, Massachusetts, 22 August 1874, he graduated from the Massachusetts Institute of Technology in 1896 with a B.S. in Civil Engineering. He began government service in 1899 as a temporary hydrographic surveyor for the Equipment Bureau of the U.S.S. Ranger, Pacific Coast. By the end of his career, McAlpine had served on numerous special projects including work as a consultant to the Panama Canal Office, the Fort Peck and Bonneville Dam projects, and to the Tennessee Valley Authority. McAlpine reviewed and approved the McArthur Lock at St. Mary's Falls Canal and in 1943 participated in conferences between representatives of the United States and Great Britain, consulting as to the feasibility of constructing artificial harbors for the proposed landing of Allied troops at Normandy. He was given Top Secret clearance after the war under Executive Order 9835. McAlpine achieved the highest civilian post in the Corps of Engineers. He was awarded the Emblem for Exceptional Civilian Service 26 August 1946. McAlpine retired from the Corps of Engineers in 1954.

[21]Lt. Col. Malcolm Elliott: Division Administrative Bulletin No. 1201, 22 December 1937, Subject: Kapok Vests (memorandum); R.L. Dean: Division Administrative Bulletin No. 1205.1, 12 July 1938, Subject: District Safety Regulations (memorandum); Schedule For U.M.V.D. Safety Meeting To Be Held In the St. Paul Minnesota District 22 and 23 June 1939; Methods of Handling Visitors (memo: undated--submitted by districts in compliance with request of this office dated 11 May 1937), Record Group 77, subgroup: U.M.V.D., Box 9, Para 5-C, SR 345-250-5, NAKCB.

The question of visitors to the construction sites was handled on a district to district basis, as were safety regulations. The St. Paul District included a comprehensive paragraph, followed in thoroughness by the Rock Island District. Interestingly, the Chicago District had no set rules; policy was set by the employee in charge. However, it was noted that "It will probably be necessary to formulate regulations as visitors are numerous."

[22]"Channel News", Old Man River 2, no. 5 (February 1938), Record Group 77, St. Paul District, Old Man River Safety Bulletins 1938-1940, Box 2, Entry 1626, NAKCB.

[23]H.M. Anderly to Alfred W. Rice, 6 December 1940, Record Group 77, St. Paul District, General Records 1934-1943, Box 39, Entry 1629, File 4013.1/28-11 to 4013.1/65, NAKCB.

[24]History of Transportation on the Upper Mississippi and Illinois Rivers, p. 89; The Corps, The Environment and the Upper Mississippi River Basin, pp. 53, 62-3; Creativity, Conflict and Controversy, p.205; "Speech of General Markham--Alma Dam" (typewritten, n.d.), p. 6, Record Group 77, St. Louis District, General Correspondence/Lectures and Addresses, 1926-1940, Box 2, Entry 1686, File 1796, NAKCB.

[25]Raymond Merritt, The Development of the Lock and Dam System on the Upper Mississippi River (Washington D.C. National Waterways Roundtable: U.S. Army Water Resources Support Center, n.d.) p. 96; Col. Philip B. Fleming, interview by Mary Proal Lindeke of WMIN Radio Station, p. 7.

[26]History of Transportation on the Upper Mississippi and Illinois Rivers, p. 82; Old Man River 4, no.1 (January 1937): 15-20; 4, no. 9 (September 1937): 12-15; 2, no.5 (December 1935): 8-13; 3, no. 8 (October 1936): 19-22; 4, no. 5, (May 1937): 16-21; 5, no.3 (March 1938): 12-18; 5, no.2 (February 1938): 2-21, Old Man River Safety Bulletins 1938-1940, Box 2, Entry 1626, NAKCB.

"Project Information: Upper Mississippi 9-Foot Channel Project prepared by U.S. Corps of Engineers Office, Corps of Engineers, St. Paul District, St. Paul, Minnesota" (n.d.) n.p. [photographs]; Leonard H. Dicke, "The Upper Mississippi River Waterway," pp. 1-5, Record Group 77, subgroup: St. Paul District, General Records 1934-1943, Nine Foot Channel Project, Box 39, Entry 1629, File 4013.1/66 to 4013.1/86, NAKCB.

Historical Resources Evaluation: St. Paul District, pp. 128-161 [site map and section elevation reproductions].

"The Upper Mississippi River Canalization Improvement", (U.S. Army Corps of Engineers, U.S. Division Engineer, U.M.V.D., St. Louis Missouri, February 1938, Revised May 1939, Revised May 1940) pp. 1-17; Lt. Col. Malcolm Elliott, "The Upper Mississippi River Project with a Discussion of the Movable Gates in the Dams," presented at the Western Society of Engineers, Chicago, Illinois, 1 November 1937, p. 3, Record Group 77, Subgroup: St. Paul District, General Records 1934-1943, 9-Foot Channel Project, Box 40, Entry 1629, File 4013.1/113, NAKCB.

[27]Leland R. Johnson, The Davis Island Lock and Dam 1870-1920 (U.S. Army Corps of Engineers, Pittsburgh District, 1985), pp. 37-41, 133; Michael C. Robinson, History of Navigation in the Ohio River Basin: National Waterways Study: U.S. Army Corps of Engineers Water Resources Support Center, Institute for Water Resources--Navigation History NWS-83-5 (Washington: GPO, 1983), passim; Roald D. Tweet, A History of the Rock Island District-Corps of Engineers 1866-1975 (Washington: GPO, 1975), p. 103; L.E. Wood, "A Nine Foot Depth Below St. Anthony Falls!", Old Man River 5, No. 5 (n.d.) p. 2-8, Old Man River Safety Bulletins 1938-1940, Box 2, Entry 1626, NAKCB.

[28]History of Transportation on the Upper Mississippi and Illinois Rivers, p. 82; S.G. Roberts, "Canalization of the Upper Mississippi River," Scientific American (February 1935): 72-74.

[29]Davis Island Lock and Dam 1870-1922, pp. 134-137; "The Upper Mississippi River Canalization Improvement," St. Louis: U.S. Division Engineer, U.M.V.D., 1938--Revised May 1939, May 1940 (typewritten) pp. 1-17.

[30]Martin E. Nelson, "Hydraulic Model Experiments--Iowa City" Old Man River 2, no. 5 (December, 1935): 27-28, Record Group 77, St. Paul District, Old Man River Safety Bulletins, 1938-1940, Box 2, Entry 1626, NAKCB; Historical Resources Evaluation: St. Paul Locks and Dams, p. 183; "The Rhine and the Upper Mississippi" The Military Engineer 30, No. 171 (May-June 1938), pp. 167-171; U.S. Army Corps of Engineers, A Study of Water Pressures On Roller Gates: Hydraulic Model Investigation, St. Anthony Falls Hydraulic Laboratory Report No. 77, University of Minneapolis, Minnesota, October 1963, p. 15 (typewritten).

According to the previously cited report, the use of roller gates in the United States was relatively new, one of the first installations being that of the Marmet Dam on the Kanawah River in West Virginia, completed by the U.S. Army Corps of Engineers, Huntington District, in 1934. Recently certain sources have noted the possibility of earlier installations in the northwestern sections of the country. Further investigations will document as to whether or not the Upper Mississippi River 9-Foot project was among the first such installations to use these combination roller/Tainter gate combinations in movable dam construction in the United States.

[31]P.S. Reinecke, "The Rhine and the Upper Mississippi" The Military Engineer 30, No. 171 (May-June 1938): 167-171.

[32]L. Ylvisaker to Dravo Contracting Company, 16 November 1932, p. 1, Record Group 77, subgroup: St. Paul District, Operations and Maintenance Files, 1931-1943, Box 395861, Entry Number 1626a, File 413b.3/05, NACB.

Contracting Engineer, M.H. Tredwell Company to United Construction Company, 12 January 1934, pp. 1-3, 3 March 1934, pp. 1-4; United Construction Company to District Engineer, St. Paul, Minnesota, 26 February 1934, pp. 1-2; Record Group 77, subgroup: St. Paul District, Box 395861, File 413b.3, NACB.

Old Man River 2, No. 5 (December 1935): 25-28, Old Man River Safety Bulletins 1938-1940, Box 2, Entry 1626, NAKCB.

Lt. Col. E.L. Daley to District Engineer, U.S. Engineer Office, St. Paul, Minnesota, 20 February 1934; Maj. Dwight Johns to United Construction Company, 20 February 1934; Lt. Colonel E.L. Daley to M.H. Treadwell Company, Inc., 17 February 1934 (4 pages); United Construction Company, Winona, Minnesota to District Engineer Office, St. Paul, Minnesota, 17 February 1934 (2 pages); M.H. Treadwell Company, New York, to United Construction Company, 15 February 1934 (2 pages); Capt. Homer Pettit to United Construction Company, 6 February 1934; Lt Col. E.L. Daley to M.H. Treadwell Company, 31 January 1934 (2 pages); Maj. Dwight F. Johns to United Construction Company, 13 February 1934; Lt. E.L. Daley to M.H. Treadwell Company, 24 January 1934 (3 pages); M.H. Treadwell Company to United Construction Company, 23 January 1934 (2 pages); United Construction Company to District Engineer, St. Paul, Minnesota (2 pages). Record Group 77, subgroup: St. Paul District, Box number 395861, File 413.b3, NACB.

[33]The Davis Island Lock and Dam, pp. 134-137; Historical Resources Evaluation--St. Paul Locks and Dams, pp. 114, 130-31; The Upper Mississippi River Project With A Discussion of the Movable Gates In The Dams, pp. 8, 12, 13-4.

[34]Ign. Dr. Tech. Arim Schoklitsch, Hydraulic Structures: A Text and Handbook, translated by Samuel Shulits, Vol. 2, (New York: American Society of Mechanical Engineers, 1937), pp. 638, 639-656, 679-681; Old Man River 2, no. 5 (December 1935): 27; William P. Creager, Joel D. Justin, Julian Hinds, Engineering for Dams, Three Volumes: Vol.1--General Designs (New York: John Wiley and Sons, Inc., 1945) p. 43.

[35]"The Upper Mississippi River Project with a Discussion of the Movable Gates in the Dams," pp. 6, 8-14, 18, 20.

[36]Lt. Col. Wildurr Willing to The Chief of Engineers, U.S. Army, Subject--Increase of pay: Martin E. Nelson, Assistant Engineer, 4 February 1930; U.S. Engineer Office, St. Paul, Minnesota, 4 February 1930, Statement to accompany recommendation for increase in pay, p. 2; Record Group 77, subgroup: St. Paul District, Miscellaneous Authorities (FY 1930) Box 8, Entry 1628, File 15/381-1 to 15/385-62, NAKCB.

[37]Capt. F. Russel Lyons to the International Nickel Company, New York, 13 August 1924, pp. 1-2, Record Group 77, subgroup: St. Paul District, Box 395861, File 413b.1, NACB.

[38]"The Upper Mississippi River Canalization Improvement", pp. 13-14; Davis Island Lock and Dam, p. 120; Rathbun Associates, "Historical, Architectural and Engineering Study--Locks and Dams 11-22 Nine Foot Navigation Project Mississippi River", December 1985, pp. II-27.

[39]L.E. Wood, "Historical Sketch: Construction of L/D No. 3," Old Man River 5, no. 3,(March 1938): 12-18; Old Man River 2, no. 5, (December 1935): 27, Old Man River Safety Bulletins 1938-1940, Box 2, Entry 1626, NAKCB.

R.R. Philippe, Associate Engineer, to District Engineer, St. Paul, Minnesota, 3 August 1936, pp. 1-3, Record Group 77, subgroup: St. Paul District, Operations and Maintenance Files, 1931-1943, Box Number 395859, Entry Number 1626a, File 329.1, NACB.

Telephone conversation 2/4/36, Maj. Johns to Maj. Arthur (manuscript transcription) pp. 1-3, Record Group 77, subgroup: St. Paul District, Operations and Maintenance Files, 1931-1943, Box 395848, Entry Number 1626a, File 313a.3, NACB.

[40]William Z. Lidicker, "Mississippi River: Lock and Dam No. 3," Old Man River 4, no. 9, (September 1937), pp. 12-15, Old Man River Safety Bulletins 1938-1940, Box 2, Entry 1626, NAKCB.

W.Z. Lidicker, "Unusual Timber and Steel Bearing Pile Load Tests at Mississippi River Dam No. 3" (26 July 1939), pp. 1-13, Record Group 77, subgroup: St. Paul District, General Records 1934-1943, Documents and Publications: Authorities for Publications of Articles, Box 22, Entry 1629, File 54.7, NAKCB.

[41]Historical Resources Evaluation: St. Paul District Locks and Dams, pp. 135, 146. William Z. Lidicker, "Soil Loading Tests On Buried Tie Plates" U.S. Engineer Office, St. Paul, Minnesota, (n.d.) pp. 1-8 (typewritten) Record Group 77, subgroup: St. Paul District, Operations and Maintenance Files, 1931-1943, Box 395851, Entry Number 1626a, File 313b.3, NACB.

Memo: Oliver Haywood, Jr., "Lateral Loads on Tie Rods", (16 September 1936, 2 pages). Record Group 77, subgroup: St. Paul District, Operations and Maintenance Files, 1931-1943, Box 395851, Entry Number 1626a, File 313b.3/10, NACB.

[42]Herbert G. McCormick and John W. Dixon, "Mississippi River Cofferdams," The Military Engineer 28, no. 158, (March-April 1936), pp. 105-08; Harry Carlson, "Report on Test of Relation Between Probe Resistance and Soil Density," (U.S. Engineer Office, St. Paul, Minnesota, 1938) pp. 1-5; Report on Investigations of Foundation Soil Densities at Dam No. 3 (U.S. Engineer Office, St. Paul, Minnesota, 1937) pp. 1-6, Record Group 77, subgroup: St. Paul District, Operations and Maintenance Files, 1931-1943, Box 395851, Entry Number 1626a, File 313b.3, NACB.

R.R. Philippe, memo: "Foundation-Lock No. 3" 12 June 1936, pp. 1-6, Record Group 77, subgroup: St. Paul District, Operations and Maintenance Files, 1931-1943,. Box 395848, Entry Number 1626a, File 313a.3, NACB; Harry Carlson, "Report on Trial Mixes for Dam Number 3," (U.S. Engineering Laboratory, Fountain City, Wisconsin, n.d.) pp. 1-6, Group 77, subgroup: St. Paul District, Operations and Maintenance Files, 1931-1943, Box 395851, Entry Number 1626a, File 313b.3, NACB.

"Discussion of Trial Mixes" (typewritten, n.d.) pp. 1-42, Record Group 77, subgroup: St. Paul District, Operations and Maintenance Files, 1931-1943, Box 395871, Entry Number 1626a, File 505.1, NACB.

E.J. Christenson, three memoranda: "Preliminary Report(s) on Load Test No. 3, 4, 5, Dam No. 3" (23 June 1937) pp. 1-2, 1-2, 1-3, Record Group 77, subgroup: St. Paul District, Operations and Maintenance Files, 1931-1943, Box 395851, Entry Number 1626a, File 313b.3, NACB.

Maj. Dwight F. Johns to District Engineer, Huntington, West Virginia, 27 June 1934; Lt. C.T. Hunt to District Engineer, St. Paul, Minnesota, 14 June 1934; "Report on Tests on Temperature Rise In Concrete Conducted At London Lock and Dam, Kanawha River, Huntington District" (n.d., typewritten) p. 1-9, Record Group 77, subgroup: St. Paul District, Operations and Maintenance Files, 1931-1943, Box 395857, Entry Number 1626a, File 405.1/11-4, 4/1, NACB.

[43]U.S. Army Corps of Engineers, "History of the Construction of Lock 6--Mississippi River--Trempealeau, Wisconsin--P.W.A. Project 11," compiled by Francis A. Landrieu, Assistant Engineer,in cooperation with Messrs. Ralph D. Salisbury, Mark Haima, George E. Oliver and Lee H. Baron, submitted by 1st Lt. F.S. Blinn, Resident Engineer, (April 1935, typewritten) pp. 16-17, St. Paul District Office Records, St. Paul, Minnesota.

[44]"The Upper Mississippi River Project with a Discussion of the Movable Gates in the Dams," p. 3.

[45]C.W. Short, R. Stanley-Brown, Public Buildings: A Survey of Architecture of Projects Constructed by Federal and Other Governmental Bodies Between the Years 1933 and 1939 with the Assistance of the Public Works Administration (Washington, D.C.: GPO, 1939), p. 509; U.S. Army Corps of Engineers, Drawings: River and Harbor Project--Mississippi River--Missouri River to Minneapolis Locks and Dams 3 through 10 (in two sheets for each complex) 30 September 1978; Jon Gjerde, HABS/HAER Inventory Cards--Locks and Dams 3 through 10, 26 February 1983.

U.S. Army Corps of Engineers, "History of Construction--Dam No. 3, Red Wing, Minnesota," (n.d.), passim; "Dam No. 4, Alma, Wisconsin," (edited by E.J. Christenson, n.d.), passim;" History of the Construction of Dam No. 5, Mississippi River 4.8 Miles Downstream from Minneiska, Minnesota," (submitted by V.C. Funk, 31 January 1936), p. 77; "History of the Construction of Dam No. 8 Mississippi River--Genoa, Wisconsin--14 September 1935--30 April 1937," (submitted by Frank E. Rutt, Jr. Engineer, Acting Resident Engineer, n.d.), passim, St. Paul District Office Records, St. Paul, Minnesota.

L.E. Wood, "A Nine Foot Depth in the St. Paul District Below St. Anthony Falls!" Old Man River V, no. 5, (n.d.): 6; Old Man River, (January, 1938): 14-16, Record Group 77, subgroup: St. Paul District, Box 2, Entry 1626, NAKCB.

William Patrick O'Brien, National Park Service, Field Inspection, 7-12 May 1987.

[46]U.S. Army Corps of Engineers, Drawing: "Mississippi River Lock and Dam Number 10--Esplanade Landscaping, February 1938, Rock Island District", Number ML10-38/3, St. Paul District Office Records, Map Division, St. Paul, Minnesota; O'Brien, NPS Field Inspection, 7-12 May 1987; Calvin D. Linton, ed., The Bicentennial Almanac: 200 Years of America. (New York: Thomas Nelson, Inc., 1975) pp. 332, 347; Henry B. Ward, ed., "The American Association for the Advancement of Science: Preliminary Announcement of the Summer Meeting To Be Held In Chicago From 19 to 30 June, In Connection With The Century Of Progress Exposition," Science 77, no. 2003 (Friday, 19 May 1933): 463, 474; Lt. Col. P.S. Reinecke, "The Rhine and the Upper Mississippi," The Military Engineer 30 no. 171 (May-June, 1938): 167-171; Official Guide Book of the Fair 1933 (Chicago: A Century of Progress Administration Building, 1933), pp. 20-25, 46-47, 52-55.

Germany did not participate in the event other than in isolated instances, perhaps because of the notable participation of Czechoslovakian, Polish and Jewish groups.

Lois Craig, et al., The Federal Presence: Architecture, Politics and Symbols in United States Building (Cambridge, Massachusetts: MIT Press, 1984), pp. 398-399.

[47]Ibid., passim; Col. Charles P. Gross and H.G. McCormick, "The Upper Mississippi River Project," The Military Engineer 33, no. 190 (July-August 1941), pp. 311-317; E.J.Christenson, "Dam Foundation Compacted by Pile Driving," Civil Engineering 9, n. 2, (February 1939): 92-93.

[48]The Lockmaster and Assistant Lockmaster's Residences at Lock and Dam Number 4, Alma, Wisconsin, are not standardized; their design is different from that of any other installation in the St. Paul District.

[49]U.S. Army Corps of Engineers, St. Paul District, Major Rehabilitation Program: Mississippi River Locks and Dams 3-10 In the St. Paul District--Overview and Cultural Resources Compliance Report With A Programatic Memorandum of Agreement, (n.d., photocopy), p. 6.

[50]U.S. Army Corps of Engineers, "History of Construction: Lock and Dam 7," (n.d., typewritten), St. Paul District Office Records, St. Paul, Minnesota, p. 44; U.S. Army Corps of Engineers, St. Paul District, A Study of Water Pressures On Roller Gates: Hydraulic Model Investigation (Minneapolis: University of Minnesota, St. Anthony Falls Hydraulic Laboratory Report No. 77, October 1963, typewritten), p. 15.

[51]U.S. Army Corps of Engineers, "History of Construction: Dam Number 3," (n.d., typewritten) St. Paul District Office Records, St. Paul, Minnesota, p. 1.

[52]Ibid., frontispiece; Historical Resources Evaluation: St. Paul District Locks and Dams, pp. 134.

[53]Major Rehabilitation Program: Mississippi River Locks and Dams 3-10 In the St. Paul District, p. 7.

[54]Historical Resources Evaluation: St. Paul District Locks and Dams, pp. 132-136; Creativity, Conflict and Controversy, pp. 206-207; "History of Construction: Dam 3," pp. 88-89, 104-105.

[55]"History of Construction: Dam 3," p. 8; U.S. Army Corps of Engineers, Drawings: Upper Mississippi River Lock and Dam 9-Foot Channel Project, 1930-1940, Map Collection, St. Paul District Office Records, St. Paul, Minnesota. See Inventory for specific citations.

[56]Ibid.

[57]Ibid.

[58]See bibliography for complete listing.

[59]U.S. Army Corps of Engineers, "History of Construction: Dam 4" (n.d., typewritten), St. Paul District Office Records, St. Paul, Minnesota, p. 1.

[60]Ibid., frontispiece; Historical Resources Evaluation: St. Paul District Locks and Dams, pp. 136-137.

[61]Major Rehabilitation Program: Mississippi River Locks and Dams 3-10 In the St. Paul District, p. 8.

[62]U.S. Army Corps of Engineers, "History of Construction: Dam 4," pp. 23, 29.

[63]William Patrick O'Brien, "Photographic Inventory: Locks and Dams 3-10," National Park Service, U.S. Department of the Interior, 1987, (typewritten), passim; "History of Construction: Dam 4," p. 80; Historical Resources Evaluation: St. Paul District Locks and Dams, pp. 136-139; Creativity, Conflict and Controversy, pp. 206-207.

[64]"History of Construction: Dam 4," pp. 57-68; U.S. Army Corps of Engineers, Drawings: Upper Mississippi River Lock and Dam 9-Foot Channel Project, 1930-1940, Map Collection, St. Paul District Office, St. Paul, Minnesota. See Inventory for specific citations.

[65]Ibid.

[66]Ibid.

[67]See bibliography for complete listing.

[68]U.S. Army Corps of Engineers, "History of Construction: Dam 5," (n.d., typewritten), St. Paul District Office Records, St. Paul, Minnesota, p. 1.

[69]Ibid., pp. i, ii; "History of Construction: Lock 5," (n.d., compiled by C.B.M, copied from original 8/31/43--pencil notation), p. 1; Historical Resources Evaluation: St. Paul District Locks and Dams, pp. 139-141; Creativity, Conflict and Controversy, pp. 206-207.

[70]Major Rehabilitation Program: Mississippi River Locks and Dams 3-10 In the St. Paul District, p. 9.

[71]Historical Resources Evaluation: St. Paul District Locks and Dams, p. 142; "History of Construction: Dam 5," pp. 2, 34, 80; Historical Resources Evaluation: St. Paul District Locks and Dams, pp. 139-141; Creativity, Conflict and Controversy, pp. 206-207.

[72]"History of Construction: Lock 5," pp. 4-6; U.S. Army Corps of Engineers, Drawings: Upper Mississippi River Lock and Dam 9-Foot Channel Project, 1930-1940, Map Collection, St. Paul District Office Records, St. Paul, Minnesota. See Inventory for specific citations.

[73]Ibid.; "History of Construction: Dam 5," pp. 2, 31-34, 37-44.

[74]U.S. Army Corps of Engineers, Drawings: Upper Mississippi River Lock and Dam 9-Foot Channel Project, 1930-1940, Map Collection, St. Paul District Office Records, St. Paul, Minnesota. See text for specific citations.

[75]See bibliography for complete listing.

[76]U.S. Army Corps of Engineers, "History of Construction: Lock 5A," (n.d., typewritten), St. Paul District Office Records, St. Paul, Minnesota, p. 1.

[77]Ibid., p. 3; Historical Resources Evaluation: St. Paul District Locks and Dams, pp. 142-144.

[78]Major Rehabilitation Program: Mississippi River Locks and Dams 3-10 In the St. Paul District, p. 10.

[79]Historical Resources Evaluation: St. Paul District Locks and Dams, pp. 142-144; Creativity, Conflict and Controversy, pp. 206-207.

[80]"History of Construction: Lock 5A," pp. 1-32; U.S. Army Corps of Engineers, Drawings: Upper Mississippi River Lock and Dam 9-Foot Channel Project, 1930-1940, Map Collection, St. Paul District Office Records, St. Paul, Minnesota. See Inventory for specific citations.

[81]Ibid.

[82]Ibid.

[83]See bibliography for complete listing.

[84]U.S. Army Corps of Engineers, "History of Construction: Dam 6," (December 1936, typewritten), St. Paul District Office Records, St. Paul, Minnesota, p. 1.

[85]Ibid., pp. 93-94; U.S. Army Corps of Engineers, "History of Construction: Lock 6," (April 1935, typewritten, photocopy), St. Paul District Office Records, St. Paul, Minnesota, pp. 47-48.

[86]Major Rehabilitation Program: Mississippi River Locks and Dams 3-10 In the St. Paul District, p. 11.

[87]"History of Construction: Dam 6," pp. 48, 56.

[88]"History of Construction: Lock 6," (April 1935), pp. 8, 9, 11, 12, 16, 17.

[89]"History of Construction: Dam 6," p. c3; Historical Resources Evaluation: St. Paul District Locks and Dams, pp. 145; Creativity, Conflict and Controversy, pp. 206-207.

[90]"History of Construction: Lock 6," passim; U.S. Army Corps of Engineers, Drawings: Upper Mississippi River Lock and Dam 9-Foot Channel Project, 1930-1940, Map Collection, St. Paul District Office Records, St. Paul, Minnesota. See Inventory for specific citations.

[91]Ibid., "History of Construction: Dam 6," pp. 48-64.

[92]U.S. Army Corps of Engineers, Drawings: Upper Mississippi River Lock and Dam 9-Foot Channel Project, 1930-1940.

[93]See bibliography for complete listing.

[94]U.S. Army Corps of Engineers, "History of Construction: Dam 7," (n.d., typewritten), St. Paul District Office, St. Paul, Minnesota, p. 1.

[95]Ibid., pp.76-78; U.S. Army Corps of Engineers, "History of Construction: Lock 7," (n.d., typewritten, photocopy), St. Paul District Office, St. Paul, Minnesota, p. 3.

[96]Major Rehabilitation Program: Mississippi River Locks and Dams 3-10 in the St. Paul District, p. 12.

[97]"History of Construction: Dam 7," pp. 36, 45.

[98]Historical Resources Evaluation: St. Paul District Locks and Dams, pp. 148-151; Creativity, Conflict and Controversy, pp. 206-207; Old Man River 4, No. 4, April 1937, passim.

[99]"History of Construction: Lock 7," pp. 2-3; U.S. Army Corps of Engineers, Drawings: Upper Mississippi River Lock and Dam 9-Foot Channel Project, 1930-1940, Map Collection, St. Paul District Office Records, St. Paul, Minnesota. See Inventory for specific citations.

[100]Ibid., "History of Construction: Dam 7," pp. 36-53.

[101]U.S. Army Corps of Engineers, Drawings: Upper Mississippi River Lock and Dam 9-Foot Channel Project, 1930-1940.

[102]See bibliography for complete listing.

[103]U.S. Army Corps of Engineers, "History of Construction: Dam 8," (n.d., typewritten, photocopy), St. Paul District Office Records, St. Paul, Minnesota, p. 1.

[104]Ibid., Frontispiece, 1-2; U.S. Army Corps of Engineers, "History of Construction: Lock 8," (n.d., typewritten, photocopy), St. Paul District Office Records, St. Paul, Minnesota, frontispiece.

[105]Major Rehabilitation Program: Mississippi River Locks and Dams 3-10 in the St. Paul District, p. 13.

[106]"History of Construction: Dam 8," p. 3.

[107]Ibid., p. 81; Historical Resources Evaluation: St. Paul District Locks and Dams, pp. 151-154; Creativity, Conflict and Controversy, pp. 206-207. Old Man River 4, No. 5 (May 1937), passim.

[108]"History of Construction: Lock 8," p. 5; U.S. Army Corps of Engineers, Drawings: Upper Mississippi River Lock and Dam 9-Foot Channel Project, 1930-1940.

[109]Ibid., "History of Construction: Dam 8," pp. 57-72.

[110]U.S. Army Corps of Engineers, Drawings: Upper Mississippi River Lock and Dam 9-Foot Channel Project, 1930-1940.

[111]See bibliography for complete listing.

[112]U.S. Army Corps of Engineers, "History of Construction: Lock and Dam 9," (n.d., typewritten), St. Paul District Office Records, St. Paul, Minnesota, p. 1.

[113]Ibid., p. 96-97; U.S. Army Corps of Engineers, St. Paul District, "History of Construction: Lock 9,"(n.d., typewritten, photocopy), St. Paul District Office Records, St. Paul, Minnesota, frontispiece.

[114]Major Rehabilitation Program: Mississippi River Locks and Dams 3-10 In the St. Paul District, p. 14.

[115]"History of Construction: Lock and Dam 9," p. 65; Old Man River 5, No. 5, (n.d.), p. 2.

[116]Historical Resources Evaluation: St. Paul District Locks and Dams, pp. 154-157; Creativity, Conflict and Controversy, pp. 206-207; Old Man River 5, No. 2, (February 1938), passim.

[117]"History of Construction: Lock and Dam 9," p. 1; "History of Construction: Lock 9," passim; U.S. Army, Corps of Engineers, Drawings: Upper Mississippi River Lock and Dam 9-Foot Channel Project, 1930-1940, Map Collection, St. Paul District Office Records, St. Paul, Minnesota. See Inventory for specific citations.

[118]Ibid.,"History of Construction: Lock and Dam 9," pp. 65, 72.

[119]U.S. Army Corps of Engineers, Drawings: Upper Mississippi River Lock and Dam 9-Foot Channel Project, 1930-1940.

[120]See bibliography for complete listing.

[121]U.S. Army Corps of Engineers, "History of Construction: Dam 10," (July 1938, typewritten), Rock Island District Office, Rock Island, Illinois, St. Paul District Office Records, St. Paul, Minnesota, p. 1; U.S. Army Corps of Engineers, "History of Construction: Lock 10," (June 1938, typewritten, photocopy), St. Paul District Office Records, St. Paul, Minnesota, p. 4.

[122]Ibid., pp. 9, 17; "History of Construction: Dam 10," pp. 13, 21.

[123]Major Rehabilitation Program: Mississippi River Locks and Dams 3-10 In the St. Paul District, p. 15.

[124]"History of Construction: Dam 10," pp. 3-8; "History of Construction: Lock 10," pp. 6-11; Historical Resources Evaluation: St. Paul District Locks and Dams, pp. 159-161; Creativity, Conflict and Controversy, pp. 206-207.

[125]Ibid., "History of Construction: Dam 10," pp. 3-8; "History of Construction: Lock 10," pp. 6-11; Historical Resources Evaluation: St. Paul District Locks and Dams, pp. 159-161.

[126]Ibid; "History of Construction: Dam 10," pp. 3-8; "History of Construction: Lock 10," pp. 6-11.

[127]"History of Construction: Lock 10," pp. 6-11; U.S. Army Corps of Engineers, Drawings: Upper Mississippi River Lock and Dam 9-Foot Channel Project, 1930-1940, Map Collection, St. Paul District Office Records, St. Paul, Minnesota. See Inventory for specific citations.

[128]Ibid.,"History of Construction: Dam 10," pp. 3-5.

[129]"History of Construction: Lock 10," pp. 6-11; U.S. Army Corps of Engineers, Drawings: Upper Mississippi River Lock and Dam 9-Foot Channel Project, 1930-1940.

[130]See bibliography for complete listing.

BIBLIOGRAPHY

Research methodology involved inspection of selected holdings of National Archives Record Group Number 77. Holdings of the regional National Archives branches in Kansas City, Missouri, and Chicago, Illinois, were examined, as well as technical resource holdings at the Linda Hall Library on the University of Missouri at Kansas City campus. Personnel records located at the Civilian Records Center at St. Louis and holdings of the St. Paul District Office, U.S. Army Corps of Engineers, were also consulted. Due to the volume of records and materials, random sampling was used in the inspection of available materials. Other collections of Record Group 77, such as those materials located at Suiteland, Maryland were not able to be consulted due to time and budgetary constraints. Photocopies of the documents cited are presently held by the National Park Service, pending final disposition of research materials involved in the project. Pertinent document copies will be filed as field records with the study as submitted to the Historic American Engineering Record, Library of Congress, Washington, D.C.

BOOKS

Armstrong, Ellis, et. al. History of Public Works in the United States 1776-1976. Chicago: American Public Works Association, 1976.

Craig, Lois, et. al. The Federal Presence: Architecture, Politics, and Symbols in United States Government Building. Cambridge: MIT Press, 1984.

Creager, William P., Joel D. Justin, and Julian Hinds. Engineering for Dams. 3 Vols. New York: John Wiley and Sons, 1945.

Hull, William J., and Robert W. Hull. The Origin and Development of the Waterways Policy of the United States. Washington, D.C.: National Waterways Conference, 1967.

Johnson, Leland. The Davis Island Lock and Dam, 1870-1922. Pittsburgh: U.S. Army Corps of Engineers, 1985.

Linton, Calvin D., ed. The Bicentennial Almanac: 200 Years of America. New York: Thomas Nelson and Company, 1975.

Mass, Arthur. Muddy Waters: The Army Engineers and the Nation's Rivers. Cambridge: Harvard University Press, 1951.

Merritt, Raymond. Creativity, Conflict and Controversy: A History of the St. Paul District, U.S. Army Corps of Engineers. Washington, D.C.: GPO, 1979.

Scarpino, Philip V. Great River: An Environmental History of the Upper Mississippi, 1890-1950. University of Missouri Press, 1985.

Schoklitsch, Ingr. Dr. Tech. Arim. Hydraulic Structures: A Text and Handbook. Translated by Samuel Shulits. 2 Vols. New York: Society of Mechanical Engineers, 1937.

Short, C.W., and R. Stanley-Brown. Public Buildings: A Survey of Architecture of Projects Constructed by Federal and Other Governmental Bodies Between the

Short, C.W., and R. Stanley-Brown. Public Buildings: A Survey of Architecture of Projects Constructed by Federal and Other Governmental Bodies Between the Years of 1933 and 1939 with the Assistance of the Public Works Administration. Washington, D.C.: GPO, 1939.

Tweet, Roald. A History of the Rock Island District Corps of Engineers. Washington, D.C.: GPO, 1975.

INTERVIEWS

Johnson, Leland. Telephone interview by author, 26 January 1987.

MANUSCRIPT COLLECTIONS

U.S. Army Corps of Engineers, St. Paul District. Civilian Employment Records, Record Group 146 (Unaccessioned). Civilian Records Center, National Archives, St. Louis, Missouri.

U.S. Army Corps of Engineers, St. Paul District. Record Group 77, National Archives, Chicago, Illinois.

U.S. Army Corps of Engineers, St. Paul and St. Louis Districts. Record Group 77, National Archives, Kansas City, Missouri.

U.S. Army Corps of Engineers, St. Paul District. St. Paul District Office Records, St. Paul, Minnesota.

MAPS

U.S. Army Corps of Engineers, St. Paul District. "Drawings: River and Harbor Project: Mississippi River--Missouri River to Minneapolis: Locks and Dams 3-10." Two sheets for each complex. Map Collection, St. Paul District Office, St. Paul, Minnesota, 1985.

_____. "Drawings: Upper Mississippi River Lock and Dam 9-Foot Channel Project. 1930-1940." Map Collection, St. Paul District Office, St. Paul, Minnesota.

NEWSPAPERS/JOURNALS/MAGAZINES

Christenson, E.J. "Dam Foundation Compacted by Pile Driving." Civil Engineering 9, no. 2 (February 1939): 92-3.

Gross, Charles P. and H.G. McCormick. "The Upper Mississippi River Project." The Military Engineer 33, no. 190 (July-August 1941): 311-17.

McCormick, Herbert G. and John W. Dixon. "Mississippi River Cofferdams." The Military Engineer 28, no. 158 (March-April 1936): 311-17.

Reinecke, P.S. "The Rhine and the Upper Mississippi." The Military Engineer 30, no. 171 (May-June 1938): 167-71.

Roberts, S.G. "Canalization of the Upper Mississippi and Illinois." Scientific American, February 1935, 72-74.

St. Paul Pioneer Press, 3 May 1934.

The Wabasha County Herald Standard, 5 March 1931.

The Winona Republican Herald, 6 February 1931.

U.S. Army Corps of Engineers, St. Paul District. Old Man River 2, no. 5 (December 1935); 3, no. 8 (October 1936); 4, no. 5 (May 1937); 4, no. 9 (September 1937); 5, no. 3 (March 1938); 5, no. 2 (February 1938); 2, no. 5 (December 1935).

Ward, Henry B. "The American Association For The Advancement Of Science: Preliminary Announcement Of The Summer Meeting To Be Held In Chicago From June 19 To 30, In Connection With The Century Of Progress Exposition". Science, 77 No 2003 (Friday, May 19, 1933): 474.

PHOTOGRAPHS

U.S. Army Corps of Engineers, St. Paul District. Photographic Collection. St. Paul District Office, St. Paul, Minnesota.

_____. Field Photographs, Lock and Dam Complexes 3, 4, 5, 5A, 6, 7, 8, 9, 10. St. Paul District Office, St. Paul, Minnesota.

PUBLISHED REPORTS

Merritt, Raymond. The Corps, the Environment and the Upper Mississippi Basin. U.S. Army Corps of Engineers, Historical Division, Office of Administrative Services, Office of the Chief of Engineers. Washington, D.C.: GPO, 1984.

"The Development of the Lock and Dam System on the Upper Mississippi River." In National Waterway Roundtable Proceedings: History, Regional Development, Technology--A Look Ahead, by the U.S. Army Corps of Engineers. Washington, D.C.: U.S. Army Corps of Engineers, National Waterways Study, Water Resources Support Center, Institute for Water Resources. Photocopied.

Robinson, Michael. History of Navigation in the Ohio River Basin. Washington, D.C.: U.S. Army Corps of Engineers, National Waterways Study, Water Resources Support Center, Institute for Water Resources, 1983.

Tweet, Roald. History of Transportation on the Upper Mississippi and Illinois Rivers. Washington, D.C.: U.S. Army Corps of Engineers, National Waterways Study, Water Resources Support Center, Institute for Water Resources, 1983.

U.S. Army Corps of Engineers, St. Paul District. Major Rehabilitation Program: Mississippi River Locks and Dams 3-10 In the St. Paul District--Overview and Cultural Resources Compliance Report With A Programmatic Memorandum of Agreement. St. Paul: U.S. Army Corps of Engineers, n.d. Photocopied.

_____. Reconnaissance Report--Major Rehabilitation: Lock and Dam Number 4 Mississippi River, Minnesota and Wisconsin. St. Paul: U.S. Army Corps of Engineers, April 1984.

_____. U.S. Division Engineer, U.M.V.D. The Upper Mississippi River Canalization Improvement. St. Paul: U.S. Army Corps of Engineers, 1938, revised May 1939 and May 1940. Typewritten.

_____. A Study of Water Pressures On Roller Gates: Hydraulic Model Investigation. St. Anthony Falls Hydraulic Laboratory Report No. 77. Minneapolis: University of Minnesota, October 1963. Typewritten.

_____. Chief of Engineers. Reports of the Chief of Engineers, U.S. Army. Annual Reports, U.S. War Department. Washington, D.C.: GPO, 1927-1940.

UNPUBLISHED REPORTS

Brunet, Patrick James. "The Corps of Engineers and Navigation Improvement on the Channel of [the] Upper Mississippi River to 1939." Master's Thesis. University of Texas at Austin, 1977.

Elliot, Malcolm. "The Upper Mississippi River Project With a Discussion of the Movable Gates in the Dams." Paper presented at the Western Society of Engineers, Chicago, Illinois, 1 November 1937.

Gjerde, Jon. "Historical Resources Evaluation: St. Paul District Locks and Dams on the Mississippi River and Two Structures at St. Anthony Falls." For the U.S. Army Corps of Engineers, St. Paul District. Contract Number NCSPD-ER-R-45, 1983.

_____. Historic American Engineering Record Inventory Cards: Locks and Dams 3-10. Washington, D.C.: Historic American Engineering Record, 1983.

O'Brien, William P. Photographic Inventory: Locks and Dams 3-10. Denver: U.S. Department of the Interior, National Park Service, Rocky Mountain Regional Office, 1987. Typewritten.

Rathbun Associates. Historical-Architectural and Engineering Study: Locks and Dams 11-22, 9-Foot Navigation Project, Mississippi River. For the U.S. Army Corps of Engineers, Rock Island District. Contract Number DACW25-84-C-0030, 1985.

Rathbun, Mary Yeater. Draft History of the Little Rock District. For the U.S. Army Corps of Engineers. Chapters IV and V. Typewritten. Photocopied.

U.S. Army Corps of Engineers, St. Paul District. Histories of Construction: Locks and Dams 3, 4, 5, 5A, 6, 7, 8, 9, 10--1935-1940. 20 Vols. St. Paul District Office, St. Paul, Minnesota. Typewritten.

U.S. Army Corps of Engineers, St. Paul District. Project Information: Upper Mississippi River 9-Foot Channel Project. St. Paul District Office, St. Paul, Minnesota. Typewritten.

UNITED STATES CONGRESSIONAL DOCUMENTS

U.S. Congress. House. Document 290. 71st Cong., 2nd sess., 1929-30.

U.S. Congress. House. Document 7. 72nd Cong., 1st sess., 1931-32.

U.S. Congress. House. Joint Res. 271. Public Res. 10. 72nd Cong., 1st sess., 1931-32.